

Electrochemical and Metallurgical Industry

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Electric Smelting for the Foundry

In the iron and steel industry the electric furnace has so far proven commercially successful for two purposes: first, for the manufacture of ferro-alloys; second, for the manufacture of high-grade steel. In the production of ferro-alloys the essential reaction is the reduction of the refractory oxide of the metal which it is desired to alloy with the iron; the electric furnace is used here because this reaction requires a high temperature. In the manufacture of high-grade steels the essential reaction is that of melting and refining; i. e., removal of undesirable impurities; the advantage of the electric furnace over the crucible process rests essentially in larger units, more durable apparatus and reduced labor cost. In a highly suggestive letter, published in this issue, a new application of the electric furnace—namely, for foundry use—is proposed by Dr. Richard Moldenke, the distinguished Secretary of the American Foundrymen's Association. Here the action would be essentially one of melting, perhaps coupled with refining. The advantages are very clearly explained by Dr. Moldenke, and we hope his communication will find due attention from both founders and electric furnace men.

Industrial Safety

At the Museum of Natural History there is held at present an exposition of safety devices, and in general of objects relating to industrial safety and industrial hygiene, under the auspices of the American Institute of Social Service. This is the first undertaking of its kind in this country, and, as a sort of prologue, a banquet was held at the Waldorf-Astoria on Jan. 28, at which the guest of honor, Governor Hughes, delivered an impressive address to a notable gathering. Much was said by other speakers, notably the Italian Ambassador, on what has been done for industrial safety in European countries, especially in Germany, France and Italy. The extensive governmental system of obligatory insurance of all workmen (in the widest sense) against accident and old age in Germany is now well known, but will hardly be imitated in other countries; it was the means by which Bismarck tried to steal the thunder from the social democrats. Governor Hughes' address, while mostly of a general nature as to the necessity of doing something for industrial safety, emphasized one point which is of importance for the general public—namely, the necessity of greater safety and comfort in transportation. Everybody will probably agree with him in this respect. Perhaps with the exception of the stockholders of some trolley companies, who will consider comfort too much of a good thing, since it is essentially the "strap-hanger" who pays the dividends of stock diluted by H₂O. On the other hand, even from a purely mercenary standpoint, safety in industrial work will appeal to everybody as an absolute necessity.

* * *

The present exposition, arranged by the American Institute

of Social Service, should be of considerable educational value, since it has been arranged from a broad and liberal point of view. It includes, of course, safety devices of all kinds. But it goes further. The section of industrial hygiene comprises improved dwellings, first aid to the injured, prevention of tuberculosis and other dread diseases harmful to the life of workmen, respirators and devices for supplying and maintaining pure air and industrial betterment, etc. Further, and this is very important, there is a long list of labor-saving machinery and apparatus. The influence of labor-saving machinery on the general uplifting of the working classes and indirectly the greater safety in industrial work, resulting therefrom, cannot be over-estimated. The invention and introduction into practice of labor-saving machines is specifically American, and may be considered perhaps to be the most important contribution of the American manufacturer to the improvement of the condition of his workingmen. Labor-saving machinery is really at the bottom of the great difference between the condition of the workingman here and abroad. In this country the workingman who has to do with labor-saving machinery is really no longer a workingman, but rather an overseer who directs the machines to work for him. It is a remarkable fact that this philanthropic policy of our manufacturers has also been good business policy. It is a fact that, in spite of very much higher wages for labor here than abroad, the cost of labor per ton of output is in many plants quite considerably smaller in this country than in corresponding plants abroad.

* * *

We may be permitted to add a few words on a subject which at first sight seems to have little to do with this matter, but which is in reality intimately connected with it. This is the way in which electrochemical methods have modified in many cases old-fashioned chemical or metallurgical practice. One has only to visit a modern electrolytic caustic and bleach plant and then to visit an old-fashioned alkali plant, and finally to compare notes as to the condition of the laborers in both plants. The electric current is such an effective agent, when properly handled, it does the chemical work so exactly and thoroughly that the workingman has little more to do than to see that he has the current always in exact control. How electrochemical methods may be essentially labor-saving methods is clearly evident in the instance of the electric furnace for making high-grade steel in competition with the crucible process. A distinguished steel man of the old school, who always used to smile skeptically when he heard of electric steel, recently told the writer of his visit to an electric furnace plant producing high-grade steel, and described how he was impressed by the great ease of operation, the great reduction of manual labor and of the number of workingmen required. Electric power may be an expensive agent—as all labor-saving machinery is expensive—nevertheless, it may pay the manufacturer to stand the expense. We quote a few figures from the report of the Canadian Commission on the Kjellin steel process (page 66). Of the total cost of making 1,000 kg. of ingots, \$37.48, the item of wages amounts to \$2.66, the electrical energy to \$1.48; that is, the wages are 7 per cent and the electrical energy 4 per cent of the total cost. Manufacturers using the crucible process should compare these figures with the corresponding figures in their own cost sheet.

The National Resources of the United States

Besides the proverbial three essential factors that make for the production of wealth, there is a fourth factor, the "entrepreneur," which, while not generally comprised by the old school of economics in the enumeration, is in this age of applied science of increasing importance. It is well nigh impossible to segregate the relative value of the four parts of the economic machine, but managing and technical skill are most often the cause of the success of any enterprise. The natural resources are, of course, of nearly equal importance for economic well being. As nature deals the cards, so the natives must play. Land is the source of all wealth. The fish from the sea, the wood from the forest, the grain from the field, and the ore from the mine are all first-hand values from Nature's vault. With practically all the requisite raw materials, America is always adequately endowed. For instance, our greatest export is raw cotton. For the needs of the civilized, and especially the semi-civilized world, cotton cloth is nowadays a prime necessity. Climatic conditions of rain and sun are only right for the production of cotton in our Southern States. If we would imagine the cotton crop sold under governmental control by a national board of clear-headed business men, whose public interest in making money for the nation would be as great as is their private interest now, the natural net monopolistic returns to the country would be enormous. Corn and wheat to feed the workers of the country are raised in abundance in the States of the great plains.

* * *

Our agricultural methods are still lax, and the value of the farm lands of the nation will be enhanced in the future. Our forests once could supply much more than our national demand for lumber. But the forests have been rapidly denuded and the demand for lumber has increased inordinately. Consequently, the price has risen to such an extent that concrete, brick and galvanized sheet buildings are used more largely. But with scientific forestry our forest resources will furnish a constant and regular supply. With regard to coal lands, the United States has been blessed above all other nations with the possible exception of China. The Appalachian Mountains, the green plains of the Middle West, the arid deserts of New Mexico are spread with great areas of sedimentary rocks of the carboniferous and cretaceous ages. Included in these formations are veins of black mineral—the stored-up sunlight of past aeons. These coal lands have made Pittsburg, Cleveland, Chicago and Pueblo great smelting centers. The steam engine and the gas engine are machines for converting this potential energy into economic values. But in this age of coal, iron and copper the economic importance of coal is without bound. As the farmer must feed our internal machinery, so the coal miner must furnish the food for our industrial machinery. Our enormous water powers, our gas and oil resources furnish similar pabulum to the industrial body. And the extent of our natural resources for making power will make the electrochemical industry the "Technik der Zukunft."

* * *

In the land of unlimited possibilities the great Mesaba iron mines are a fitting place for the head waters of Niagara. The great value of the self-fluxing ores of Alabama and Tennessee, so close to the industrial heart of the new South, is just now being made apparent. The great copper mines of Montana,

Michigan and Arizona have given America the lever with which to move the copper market of the world. Recent finds in Cananea, Arizona, Utah, Nevada, British Columbia and California show the existence throughout the Cordilleras of a great copper belt. The gold and silver mines of the country are large, but the production of gold and silver is increased by precious bullion recovered as by-product in lead and copper smelting. The zinc mines of the country are large, and the supply of spelter will be greater as our metallurgists improve their methods of treating low-grade lead-silver-zinc ores. Taken all in all we have a precious heritage in our wonderful natural resources. America should conserve them and utilize them with a maximum net efficiency over a long period of years, and not carry out an inefficient maximum production over a short period of years. There has been too much wasteful attack of our inheritance. A wise but restricted paternalism and a free and educated public opinion,—the sheet-anchor of a republic that must be individualistic in most respects will stop this economic "race suicide." Then we will see a more sensible and even development of Nature's bounty.

Engineering Prophecy

Prophets are divisible into two main classes, the prophet pessimist and the prophet optimist. The reason why the prophet is without honor in his own country is because pessimism is the keynote of many prophecies, and no person is more exasperating than the friend whose assertive "I told you so" merely pours corrosive sublimate upon the sores of defeat. The prophet optimist scores in two ways. Optimism is always pleasant, particularly to him who, vexed with the woes of Pandora's box, clings to the remaining gift of hope as his only solace. At such times the optimist reaps his reward in immediate popularity as a jolly good fellow. Later, if the prophet optimist's views are vindicated, there comes the further reward of being hailed as far-sighted. If immediate vindication does not result he can, if he has fixed no time limit for himself, claim all futurity for his prophecy to come true. The prophet pessimist stands to lose all round in the esteem of his fellows. Mankind, bewitched by an old fallacy in a new garb, confident of the Dorado or Utopia round the corner, objects to the embittered individual whose dyspeptic forebodings are as grit in the bearings of the axles of progress. That is the first stage in the unpopularity of the prophet pessimist. The second stage has two alternative sides. If the view of those who differed from the pessimist has been more or less vindicated, he reaps his reward in the scorn his contemporaries lavish on his narrow vision. If, on the other hand, the pessimist proves to be right, he will be well advised if he assumes to share the depression which his fellows suffer. Should he be human enough to remark on his own foresight, his unpopularity will be even greater than in the first stage.

In the realizations of engineering progress, time has confounded both optimist and pessimist alike. More often than not the pessimist has been the worst confounded. The optimist, on the other hand, is often aghast at his previous moderation, and wishes that he had advanced speculative views of greater daring in the first instance. Yet, despite the dangers of prophecy in its social sense, it is necessary that in discus-

sion of engineering problems, in papers presented before scientific and technical institutions, the prophetic note in the scientific sense should be struck. Not the note of the romancer of the Jules Verne school, but rather the forecast of the seer who has traveled some little distance along the road through a wilderness of difficulties towards a promised land; in short, towards the Utopia round the corner. The broad division between pessimist and optimist may be applied, however, to most of these cases, except to such addresses or papers as are the retrospective history of a year or a decade of progress. The bias must, on the whole, lie towards optimism, though it requires more courage to be pessimistic. For this means that the speaker tends to stake his reputation on a negation, and his thesis often implies an accumulated burden of fruitless endeavor before the boundaries confronting him were declared insurmountable. Moreover, engineering precedent shows the pessimist as more frequently wrong. Certain unfortunate precedents have furnished ready weapons wherewith the modern pessimist is assailed. These are so notorious that they need not be cited.

* * *

Yet, as a simple point in the law of evolution, no continuous rate of progress to any goal endures for any period at the same momentum. Temporary accelerations in the direction of motion are at times afforded, while other forces either retard or divert that motion to right or left. In science progress has recently been so rapid that according to all natural laws something may be said for the anti-optimistic school, and a period of slower apparent progress and a longer assimilative period given to the development of stamina may intervene. As for the prophet optimist, him we do not propose to advise. But to the prophet pessimist we would suggest that he should not declare progress in his sphere to be impossible because for the moment the river cannot be forded. Rather should he be moderate in his pessimism, nay, even be an optimist. While declaring, and often quite truly, that with the facilities at his command immediate progress along one path may be checked, he might reasonably safeguard himself by declaring that with further progress by others along allied and parallel paths, that which is insurmountable to-day may yet be bridged by help to be secured in the future from other wings of the army of science. Much has been done by a harking back to a branching of the ways traveled, and attacking the closed door with the instruments and appliances of a later day. As to tangible reward for the prophet pessimist we do not see much that is agreeable. He may, however, do most useful service with less unpopularity if he refrains from declaring that progress is impossible and will admit a saving clause into his prophecy. As to the reward of the prophet-super-optimist, we do not know if he needs any. Virtue (or an assumption of it, which amounts to the same thing) is said to be its own reward. We may leave the prophet optimist to his idols and ideals, chimeric though the latter may seem. But so far as the future of a striving and virile race goes, we probably owe more than is generally conceded to the prophet pessimist. The very negation must in such a race spur the workers to greater striving. An affirmative forecast is not always soul-inspiring to an energetic race, although it may serve to soothe a generation of short-sighted serfs, just as opium soothes its emasculated devotees.

The Iron and Steel Market.

The situation has not lost a particle of its strength, and the iron and steel market continues to be the strongest, in point of tonnage and steadiness, which has ever been experienced. The United States Steel Corporation reported that on Dec. 31 it had 8,489,718 gross tons of unfilled orders on its books, which is the largest yet reported at the quarterly periods, and shows a gain of 552,834 tons for the quarter, a gain of 884,632 tons in a year, and a gain of 3,793,515 tons in two years. During January orders were heavier than shipments, so that there has been a further gain, but as buyers are now well covered it is probable that the tonnage on March 31 will be somewhat smaller, unless, indeed, books are opened for 1908 rail orders, in which event a further increase may possibly be shown.

There have been few changes in prices of finished steel products. Effective Jan. 24, galvanized sheets were advanced \$.00 per net ton, galvanized corrugated roofing 10 cents per square, and blue annealed sheets \$.10 per ton. The advances in galvanized products were due to the high price of spelter, which towards the close of January reached 6.85c., New York, against an average price during 1906 of less than 6.25c. Outside of a short-lived boom in 1899, the present spelter market is by far the highest on record. Effective Jan. 25, merchant steel pipe was advanced 1 point, or about \$.20 per net ton, making the "official" price on jobbers' carloads 75 per cent off list, on sizes 3/4 to 6-inch, inclusive, the actual market on large lots being 76 and 5 off. This is the third 1-point advance since the 2-point advance Oct. 13, making the total advance about \$10 a net ton. Independent tin plate mills are booking third quarter business at 10 cents a box above the regular market, the leading interest not making regular sales for third quarter, and this points to a general advance in tin plate before long.

Advances have been quite general in the past four months, putting finished steel products, with the exception of shapes and rails, up from \$3.00 to \$10.00 per ton. Soon these advances will begin to be felt by consumers; at present practically all material is going out on old contracts. The advances are sufficient to exert an influence in the direction of curtailing consumption, but in the present alignment of the market the universal feeling is that if there is any impending danger it is that of financial troubles or general business uncertainty; with a continuance of fairly satisfactory conditions in this respect the iron and steel market seems certain to carry itself well through the present year.

Sooner or later a depreciation must occur in the iron trade, whether mild or severe remains to be seen. It is becoming increasingly difficult to finance undertakings. A symptom of the underlying conditions as regards the financing of railroad expenditures is found in the arrangements made by the Pennsylvania Railroad Co. early in January, by which it has authorized \$100,000,000 of car trusts, to be issued in series of \$1,000,000 each; twenty-five of these series are to cover cars ordered for 1906 delivery, and nineteen are to cover cars ordered for 1907 delivery. Most of the 1906 cars are already delivered, yet these certificates are to be issued some time in the future, and the railroad expects to purchase a part of them itself, retaining them in the treasury until a better opportunity is afforded to dispose of them to the public. If the greatest railroad system in the world has such difficulty in financing cars already ordered, and largely delivered, it certainly will not be easy for other railroads to finance all the expenditures they may be willing or even anxious to make.

PIG IRON.

Early in January some fairly heavy buying occurred for second half delivery. The market later became uneventful. Towards the close of the month two apparently opposing currents set in; in the East prompt pig iron was offered at con-

cessions, and sellers appeared anxious to make sales, while at the same time in the Central West and the South there developed fairly heavy buying for second half at full prices. In the ultimate analysis it will probably be found that the easier tone in prompt iron was but the natural adjustment called for by conditions, since so great a spread between prompt and future deliveries could of necessity be but temporary. The indications are that the pig iron market will be strong for the greater part of the year. The engagement of iron for import has about ceased, although a fairly large tonnage is yet to come in. The Jones & Laughlin Steel Co., at Pittsburg, is embarrassed, as early in the month its No. 2 Eliza furnace broke out, causing the loss of several lives and necessitating an indefinite suspension, while towards the close of the month it was decided to blow out No. 5, as it was slipping badly, and another accident was feared. This leaves it with only about 65 per cent of its normal capacity in blast, and the pig iron market is such that it is impossible to purchase any adequate quantity. The valley (Mahoning and Shenango) market stands as follows: No. 2 foundry, prompt, \$25.00; second half, \$21.50 to \$22.00; Bessemer, \$22.50 for nearby delivery, \$22.00 to \$22.50 for second quarter, and \$21.50 for second half; basic, 25 to 50 cents less than Bessemer; prices delivered Pittsburg, 85 cents higher. In the South, Sloss, Tennessee and Republic are holding for \$19.00 for second half, while there are a few sellers at \$18.50. Feb. 1 the Southern roads advanced their rates 25 cents to Ohio River points, while the Northern roads made an advance of 20 cents to certain points. The rate from Birmingham to Pittsburg is now \$4.85; to Chicago, \$4.35; to New York the rail and water rate advanced 25 cents to \$4.25.

BILLETS AND SHEET BARS.

The market has become a trifle easier. Shipments on regular contracts by the large interests are improved, while some of the smaller interests are offering steel. The new open-hearth steel interest on Staten Island, Milliken Bros., is offering some steel; the Portsmouth (Ohio) Steel Co. has offered some steel, and the Republic Iron & Steel Co. and the Youngstown Sheet & Tube Co. appear to be offering steel somewhat more freely. We quote Bessemer billets on the basis of \$29.00 f. o. b. Pittsburg, and open-hearth billets on the basis of \$30.00 f. o. b. Pittsburg, although it is possible that the steel could not actually be put into Pittsburg at these figures. Sheet bars can be had for forward delivery at \$29.50 f. o. b. Youngstown.

FINISHED STEEL.

We quote finished steel prices as follows, unchanged from last report, except in the case of galvanized sheets:

Standard rails, 50 pounds and heavier, \$28.00 at mill, except that Cambria and Pennsylvania are obtaining \$30.00 on early delivery; light rails, \$34.00 in carloads and \$33.00 in large lots f. o. b. Pittsburg, for sections 25 to 45 pounds.

Structural shapes, 1.70c. for beams and channels, 15 inches and under.

Plates, 1.70c. for 1/4-inch and heavier, for indefinite delivery; as high as 2c. is obtained by the smaller mills for quick delivery.

Merchant steel bars, 1.60c. base.

Sheets, 2.60c. for black and 3.75c. for galvanized, No. 28 gauge; blue annealed, 1.85c. for No. 10 gauge.

Tin-plates, \$3.90 for 100-pound cokes.

Removal of Sulphide of Zinc Accretions in Reverberatory Forehearth.

Where a reverberatory forehearth is used entirely independent of the lead furnace to separate out the last globules of metallic lead and copper-lead matte from the slag, the sulphide of zinc separates out from the slag and "mucks up" the tap-holes as sometimes the entire hearth. The exact

nature of the process is not known, but probably the zinc sulphide is carried in "igneous solution"—at least a convenient term if not an explanation—and thrown down in the oxidizing atmosphere and lower temperature of the forehearth. An easy practical way to remove these accretions is to add scrap cast iron. Cast iron is used because of its lower fusion point. This decomposes the zinc sulphide, forming iron sulphide and metallic zinc. The latter boils off and burns with its well-known white fumes. This is used with more or less success by several of the large lead smelters. It is one of the nice little tricks of the trade.

American Electrochemical Society.

The next annual meeting will be held on the 2d, 3d and 4th of May (Thursday, Friday and Saturday of the first week of May), at the University of Pennsylvania, Philadelphia, Pa.

The following gentlemen were elected members at the January meeting of the board of directors: Messrs. B. B. Burling, Lancaster, Pa.; C. L. Speyers, New Brunswick, N. J.; H. P. Wood, Urbana, Ill. At the February meeting of the board of directors the names of the following gentlemen will come up for election: Messrs. S. T. H. Hall, Helena, Mont., and J. Henry Lienau, New York City.

At the next annual meeting, in Philadelphia, there will be a general discussion of problems of a scientific or engineering nature on subjects bearing on electrochemistry. Some time ago the board of directors authorized the secretary to ask the members of the Society for such problems, for the purpose of publishing the same and securing a discussion. There has been quite a liberal response to this request, and the secretary has now published a list of those problems. Part of it is given below. The remainder will be published in our next issue.

Fixation of atmospheric N by electric current.

Production of HCl from electrolytic chlorine.

Decomposition voltages of salts in fused condition.

Conductivity of various fused baths.

Heat formation of alloys and alkaline and alkaline-earth metals with "heavy" metals.

Direct electrolytic separation of Zn from ZnS concentrates, or roasted ZnS. (Fused bath.)

Search for electrode and furnace materials which will resist various fused baths.

Uses of Cl and the several alkali and alkaline-earth metals.

Investigation as to relative melting points of the rarer elements and oxides from 1,200° to 2,800° C.

Anodic behavior of carbon electrodes in relation to the combination of carbon, hydrogen and oxygen—an application of electrochemistry to one of the fundamental problems of organic chemistry.

The mechanism of the reactions which result in ferrate as one of the products of the electrolysis of alkaline chloride solutions and the conditions governing the amount produced.

Are catalytic reactions electrochemical?

The resistance and temperature coefficient of various metals and alloys.

The electromotive forces between different metals and solutions.

Phenomena in a porous diaphragm.

Intermediate electrodes.

Does it take more electromotive force to deposit a liquid metal than a solid metal from an electrolyte?

Electric conductivity of melted metals, at various temperatures.

Preparation of carbon black from natural gas.

Thermochemical data for carbides.

Does the presence of an electrically-conducting pigment in a linseed oil paint applied to an iron structure tend to promote corrosion?

The conditions affecting the corrosion of steel and other alloys.

Data with regard to the deterioration of graphite anodes at different temperatures, with different fluxes and slags and with reference to possible specific gravities of the graphite electrodes.

Effect of temperatures (aqueous solutions) on the life of graphite anodes (a) with stationary electrolyte, (b) with circulating electrolyte.

The production of metallic antimony from stibnite.

A further investigation of the ionization of carbon, and experimental work tending to utilize carbon directly for the generation of electricity.

Is the electrolytic preparation of bleaching solution for pulp a success?

An economical method for the recovery, by electrolysis, of the copper contained in the water pumped from copper mines. The composition of this water is as follows: Free sulphuric acid, 0.1200 grams per liter; arsenic, 0.00915; antimony, 0.00570; copper, 0.1573; iron, total, 0.2310. The copper and iron are both in solution as sulphates. Large quantities of this water are pumped from the Butte and other copper mines, and the present practice is to run the water over scrap iron and obtain a precipitate running 50 per cent copper, which is subsequently treated in furnaces with more or less loss.

The behavior of metallic silicon as an anode in chloride solutions.

CORRESPONDENCE

Card Index.

To the Editor of *Electrochemical and Metallurgical Industry*:

SIR:—It seems probable that American electrochemists do not realize the present standing of the proposed card-bibliography of the current periodical literature of electrochemistry which the Concilium Bibliographicum, of Zurich, intends publishing.

The preliminary work towards its production has been completed, but no regular printing of the references has been done.

The Concilium, from its experience gained through publishing other card-bibliographies during a period of more than ten years, knows exactly the cost of their production.

To make this branch—electrochemistry—self-supporting will require seventy-five subscribers to the complete set of cards.

The manuscript of the Section of Electrochemistry will not be printed until this number of subscribers has been secured; but the Concilium will then assure its subscribers of a complete set of references to the original work being published the world over on electrochemistry, and will guarantee that the bibliography will not limp along for a year or two and then cease to exist, but that it will be continued.

The Concilium will ask no payments of subscribers until the first half-year's cards have been delivered to them.

If electrochemists of America believe that a card bibliography, arranged minutely by subjects, would be of value to them or to the institutions which they represent, now is the time to act on that belief and to contribute their support by subscribing to this branch of the work of the Concilium.

Communications may be addressed through February and March to the writer at the address given below.

A. L. VOGEL.

214 A Street, S. E., Washington, D. C.

Water Gas.

To the Editor of *Electrochemical and Metallurgical Industry*:

SIR:—In your January issue is a translation by Dr. Nagel of Baron Jüptner's article on water gas, taken from the latter's "Chemische Technologie der Energien." This letter is written not to criticise the translation, which is well made, but to criticise two glaring errors in the original which remain

unchanged in the translation, and which shall be corrected here.

When carbon burns to CO^2 , 97,600 Calories are generated per 12 kg. of carbon burning (we agree with Jüptner); when molecular weight of CO (containing 12 kg. of carbon) burns to CO^2 , 68,700 Calories are evolved (we agree again with Jüptner); but when 12 kg. of carbon burns to CO, Jüptner says that 21,100 Calories are evolved, whereas, from his own figures, just given, and with which we substantially agree, there is evolved $97,600 - 68,700 = 28,900$ Calories.

Jüptner should have used 28,900 instead of 21,100, to have his figures consistent with each other; I prefer a slightly different value, 29,160, which is 0.9 per cent higher, but there is no shadow of doubt that the figure 21,100 is some 8,000 Calories below the correct figure, an error of 28 per cent.

The second error is that Jüptner takes 69,750 Calories as the heat of formation of a molecule of steam or water vapor, whereas, this is the heat of formation of molecular weight of liquid water. When steam is passed over incandescent carbon, steam is the thing decomposed, and not liquid water, and, therefore, the heat of formation of water vapor, which is 58,060 Calories, is to be supplied per molecular weight of steam decomposed. Jüptner's figure is therefore 11,690 Calories too high, an error of 20 per cent.

The fundamental equation of the production of water gas being $\text{C} + \text{H}^2\text{O} = \text{H}^2 + \text{CO}$, and Jüptner having erred 20 per cent on one and 28 per cent on the other of the heat quantities involved, we can infer that no value at all attaches to his discussion of the thermochemistry of this reaction.

JOSEPH W. RICHARDS.

Lehigh University, Bethlehem, Pa.

To the Editor of Electrochemical and Metallurgical Industry:

SIR:—Referring to Dr. J. W. Richards' letter I would say that the figure given for the heat of formation of CO in the January article is an overlooked misprint. The same figure, however, is correctly given in the October article of last year; furthermore, this mistake does not interfere with the correctness of the rest of the article, which contains a great deal of valuable and original information. Relating to the combustion heat of H_2 , Jüptner is using the figure for liquid water; whether this is proper is somewhat a matter of opinion. However, by these accidental mistakes the value of the work, which is considered in Europe the most prominent of its kind, is not at all diminished.*

In the translation of the complete work, which is now in preparation, these misprints or mistakes will be carefully corrected.

OSKAR NAGEL.

NEW YORK CITY.

Electric Smelting for the Foundry.

To the Editor of Electrochemical and Metallurgical Industry:

SIR:—For some time past foundrymen have been interested in the developments of electric smelting so far as it might be applied to their industry. As the necessary information as to whether iron may be melted in a commercial way can only be given by our electrical friends, perhaps a few remarks on the requirements involved may be of use to those who have apparatus and processes adapted for foundry work.

The average foundryman of to-day has constant calls for steel castings along with his regular routine work in gray iron. This, on account of the rapid introduction of the steel casting into machine construction. These steel castings he must sub-let to the steel foundries. The latter are looking for tonnage, and do not like to fill up with small quantities of comparatively light work. Hence high prices, which cut the foundryman's profit. In a similar way the foundryman has to deal with malleable castings. The malleable castings founder has both steel and gray iron put up to him, and it may not lie very far in the future when the steel founder may be asked

to produce both gray iron and steel castings along with his steel. It is to be understood, of course, that this is all brought about in making contracts with concerns who place their work by the year, or the thousand tons, be the castings what they may during the period of contract.

Now, very few foundrymen are equipped for this. They strive to place these outside lines with other people at the smallest loss to themselves. Yet if there were a convenient and easily operated process, many of them would install it immediately to take care of just such conditions.

The smelting, or rather plain melting, of iron electrically has always seemed to me ideal in its way. We do not want to produce chemical changes in our mixtures if we can help it. We want only to melt quick, produce very hot iron, and punish the metal as little as we can. Every time we melt the metal under present conditions we hurt it somewhat, the degree of the damage done depending upon a number of conditions, both chemical and physical. We counteract this by additions of steel to reduce the total carbon, or selecting the silicon content in such a way that with the reduction in this element incident to the process, a strong iron results. If, however, we could have a process which in no way changes the composition, we could put into the melt just what we want out of it, and one of the serious difficulties of foundry metallurgy would be solved. Again, if we could regulate the temperature in such a way that the iron is not overheated while melting, but can be heated up very high afterwards, we could obviate the oxidation of the metal during the melt, and in addition remove any existing evil of that kind by the use of ferro-manganese in the melt when it has been brought to practically a steel temperature, at which point the ferromanganese will do its work.

The induction furnace, it seems to me, fills these requirements, and I would like to see more work done along this line for the foundry. I may be in error, but it would seem to me that scrap of all kinds, properly selected, is all that need be melted, cleaned by some ferro-alloy, and then cast in the usual way. The enormous steel production will always yield scrap enough to supply the demand for small steel castings, once a process of this kind can be made to work commercially, and I would be very glad to be of assistance in bringing a process of this kind to the attention of the foundry world.

Taking the non-ferrous metals. A brass foundry would have abundant use for an electric smelting process, if run on the lines laid out above. The melting loss in the brass foundry in zinc and tin is a great one, and one that runs up into money quickly. A clean, wasteless process, as the electrical one should be, would be a boon to the industry. There are many foundries which could melt within short periods of time during the day or night when their plant is not used for its regular purposes. Hence only the electrical apparatus proper might be required, the necessary power being available.

The foundry has practically every melting process under the sun in use for making the various classes of castings. We see the open-hearth, the Bessemer and the cupola, the air furnace and the crucible in operation everywhere. Yet every metallurgist knows that the crucible process gives the best metal, if you can stand the cost. Now, the electrical furnace, if the melting proper is conducted so that the advantages of the crucible process are retained; that is, the temperature not allowed to exceed safe limits, and the metal kept from oxidizing influences, is bound to give the highest class of product, and it seems to me with the greatest ease of manipulation.

I would therefore urge the study of this line of work in contradistinction to the smelting of steel from ore; in other words, to simply melt, instead of completing the cycle of operations in a metallurgical process. The great foundry industry is ready to take this up once the commercial feasibility has been demonstrated, and I therefore present the problem to the electro-metallurgical fraternity with my best wishes.

WATCHUNG, N. J.

RICHARD MOLDENKE.

McDonald Electrolytic Bleach and Caustic Soda Plant.

By J. R. CROCKER.

The art of producing caustic soda and chlorine gas to satisfy the great diversity of its uses, and its ever increasing consumption in the industrial arts, has demanded the attention of the best talent in the chemical and electrochemical field. Innumerable attempts have been made for producing these products strictly along chemical lines; that process being the most successful where the cost of raw material was the least, or where the by-products could be reclaimed in a manner profitable.

America, unhampered by the more obsolete methods followed in Europe, and with its unlimited resources for pro-

Johnsonburg, Pa. This plant has been in operation for over one year, and has a daily capacity of 16 tons of bleaching powder and $6\frac{1}{2}$ tons of caustic soda.

Figs. 1 and 2 represent the engine room and switchboard. The walls and floors are of tile, and the exposed iron work is coated with white enamel. The generating units are direct-current, compound-wound generators, constructed so that each will operate without sparking at a voltage varying from 180 to 270, and capable of supplying 2,000 amps. to the cell sets arranged in series-multiple. These generators are direct connected to vertical, cross-compound condensing engines, with a



FIG. 1.—ENGINE ROOM.

ducing cheap power, was ripe for the introduction of electrochemical methods to enlarge and improve upon the general chemical industry. Therefore, it was not long before this country was industriously pushing to a conclusion the most



FIG. 2.—SWITCHBOARD.

effective system pertaining to cheapening the cost sufficiently to compete with foreign trade. Consequently, there have been developed several systems for the production of caustic soda and chlorine gas by the electrolysis of sodium chloride.

Naturally, the most successful is the one where the economy of maintenance and operation, in conjunction with high efficiency, has proven beyond the skepticism of the investor the true facts of its merits. Such a process as this is illustrated herewith in a plant installed by the McDonald Electrolytic Co. for the New York & Pennsylvania Co. at their paper mill at



FIG. 3.—CELL ROOM ON SECOND FLOOR.

rating of 750 hp. at 100 pounds steam pressure at the throttle. The exhaust of these engines is conducted to a condenser. The switchboard is so constructed as to operate the individual cell units independently, their regulation being governed by a separate ammeter to each unit. The auxiliary machinery, such as a motor-generator set for lighting 200 16-c.p. incandescent lamps, and a 100-hp. motor for driving the agitators in the bleach liquor tanks, derive their power from the main units.

Figs. 3 and 4 illustrate the cell rooms. Fig. 3 shows the second floor, containing 250 cells and the chlorination towers, to which the chlorine gas is delivered under a slight suction. Fig. 4 shows the third floor, upon which are located 350 cells. All of these cells are connected up in series-multiple of 50, and so connected at the switchboard as to be interchangeable.

On the first floor are located the bleach liquor tanks, with a



FIG. 4.—CELL ROOM ON THIRD FLOOR.

combined capacity of 72,000 gallons of bleach liquor. There are also located at this point the brine mixing and storage tanks. The plant, as a whole, is constructed so as to facilitate its operation with as small an amount of labor as possible. The brine solution is supplied to the cells automatically, and the

products resulting from its decomposition are handled without undue expense.

The chlorine gas upon delivery to the chlorination towers is immediately taken up by the milk of lime, and after repeated circulations is brought up to the required per cent of available chlorine, whereupon it is delivered to its point of consumption by the aid of a system of piping and rotary pumps. The caustic soda leaves the cell at a density of 15° B., and is delivered to an Ordway evaporator, illustrated in Fig. 5, located in an adjoining building. The evaporator receiving the solution at 15° B., 5 pounds steam pressure concentrates it to

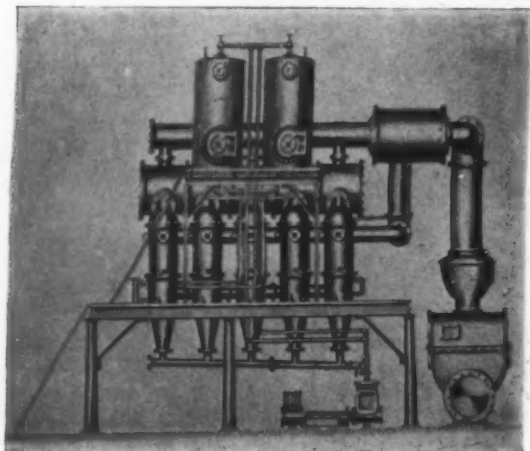


FIG. 5.—ORDWAY EVAPORATOR.

45° B., and during this operation the salt is practically eliminated. By the introduction of this evaporator there is furnished the connecting link to a most complete system for producing a finished product from the raw material.

It has been found by the New York & Pennsylvania Co. that the repairs and replacements on the plant, as a whole, have been abnormally low, and I am told that their cells have been in operation over eight months without being disturbed, and, when finally taken apart, the replacement of the anodes was the only requirement. The results produced by this plant have attracted chemists both in this country and abroad, especially as many tests as to its efficiency have substantiated the claims set forth by its makers.

Metallurgical Calculations.

By J. W. RICHARDS.

Professor of Metallurgy in Lehigh University.

THE OPEN-HEARTH FURNACE.

By the above title we mean to designate not only the regenerative gas furnaces for making steel but also those for reheating purposes; in other words, regenerative or recuperative reverberatory furnaces. Prominent among these is the Siemens-Martin furnace, with complete gas and air preheating regenerative chambers. In all these furnaces the charge is heated, or kept hot, partly by direct contact with the gaseous products of combustion and partly by radiation from the flame and the sides and roof of the furnace. It was the Siemens brothers who first insisted on the relatively great importance of the radiation principle, in distinction to the direct impingement of the flame on the material, pointing out that a luminous flame radiates from all parts of its volume, while a hot, solid body radiates only from its surface, and direct impingement interferes with the development of perfect combustion and communicates heat relatively slowly at best.

GAS PRODUCERS.

Gas producers are the usual adjunct for open-hearth furnaces, excepting where natural gas or blast furnace gas is

available. They may be placed far from the furnace, when they deliver cool gas to the regenerators, or close to the furnace, delivering comparatively hot gas to the regenerators, or even be made part of the furnace itself, delivering their hot gas immediately to the ports of the furnace. The latter is undoubtedly the most economical arrangement where practicable.

The following generalizations concerning the relations of the gas producer to the open-hearth furnace may be made: Producers furnish 4,300 to 4,600 cubic meters of gas per metric ton of coal used (150,000 to 160,000 cubic feet per short ton); the gas produced runs 3 to 8 per cent CO², 5 to 20 per cent H², 20 to 30 per cent CO, and 50 to 60 per cent N²; its calorific power is 750 to 1000 Calories per cubic meter (47 to 63-pound Calories, or 85 to 115 B. T. U. per cubic foot); its calorific power represents 60 to 90 per cent of the calorific power of the fuel used; in steel-making processes, the keeping of the furnace up to proper heat requires the gasifying of 25 to 35 kilograms (50 to 80 pounds) of coal per hour, in the producers, for each ton of metal capacity of the furnace; good producers gasify 60 to 65 kilograms of coal per hour per each square meter of gas-producing area (10 to 15 pounds per hour per each square foot); a furnace therefore requires some 0.4 to 0.6 square meter (4 to 6.5 square feet) of gas-producing area in the producers for each ton of metal capacity of the furnace.

FLUES TO FURNACE.

In conducting the gases to the furnace, the flues or conduits should be of ample size. If too small the gas must pass through them with high velocity, requiring considerable draft to give them this velocity, which the chimney or blower may or may not be capable of furnishing. Producers are almost always worked by a steam blower, furnishing mixed air and steam and a plenum of pressure in the upper part of the producer, which suffices to send the gas through the conduits under a slight pressure, and thus avoids any sucking in of air through crevices in the conduits. With too small conduits the resulting friction and high velocity required may give the blower more work than it can do, and thus entail demands for draft upon the furnace stack. A reasonable rule is to give the flues such cross-sectional area that the hot gas which must pass through them shall have a velocity between 2 and 3 meters per second.

REGENERATORS.

The dimensions of the regenerators are of the first importance to the working of the furnace. They should have sufficient length in the direction the gas currents are passing, so that the gases may be properly cooled or heated; they should have sufficient cross-sectional area of free space, so that the velocity of the gases through them is not too great; they must have sufficient thermal capacity, so that they can absorb the requisite quantity of heat.

Length.—From 4 to 6 meters (13 to 20 feet) is a suitable length in the direction of the gas currents. This permits the hot products to become properly cooled before going to the chimney, and the gas or air to be properly heated before entering the furnace. The shorter length may be used when the regenerator is of large cross-sectional area, with slow velocity of gas currents through the free spaces; the longer when the regenerator is rather restricted in cross-section and the gas currents have somewhat high velocity.

Cross-Section.—The free-space sectional area should be such that the gases where hottest should not have a calculated velocity of over 3 meters (10 feet) per second, and if calculated for 2 meters (6.5 feet) will give much better results as regards transmission of heat to the checker work. In this manner, knowing how much gas must go through the regenerator and what its maximum temperature will probably be, the cross-section area of free passage space can be calculated. The relation of this to the cross-section of the entire stove must next be considered, and this is entirely a question of how the checker work is built up. If the bricks are stacked close together the free space may be reduced to as much as one-half the total;

as ordinarily stacked it may be 60 to 80 per cent of the total; if perforated bricks are used, as in blast-furnace firebrick stoves, the area of free space averages one-half the total; with ordinary bricks the average is 70 per cent. This is a question which is very variously worked out in different furnaces, and to which not as much scientific thought has been given as should be. The thickness of the bricks influences greatly the relative amount of free space and filled space, and the rate at which the regenerator heats up or cools off. In a regenerator of given length and cross-section closer packing of the bricks gives more heat absorbing surface, increases the velocity of the gases and diminishes the cross-sectional area of each passage and of the sum of all the passages; some of these factors increase the efficiency of the regenerator, others tend to decrease it, and there are, therefore, several independent variables to be considered in finding the best arrangement for highest efficiency. A numerical solution is indeed a possibility, but is too involved for an elementary presentation of the subject.

Relative Sizes.—The relative sizes of gas and air regenerators is a question of importance which admits of easy solution by calculation. So far we have treated the pair of regenerators together, and discussed the sum of their cross-sections as deduced from the volume of products passing through at an assumed maximum temperature and allowable velocity. The regenerators at one end of a furnace are, however, usually divided into a pair or set, one for heating gas and the other for heating air. This is not usual where natural gas is used, because of the deposition of soot in the regenerator by the latter when it is heated, but nine out of ten open-hearth furnaces preheat their gas as well as the air. The heating capacity of the regenerators should be divided in proportion to the calorific capacities of the gas and air simultaneously heated. The problem is therefore to find the heat capacity per degree of the gas and air used, or, more exactly, the total heat capacity of each of these between the temperature at which they enter the regenerators and that at which it is desired that they should enter the furnace.

Problem 66.

An open-hearth furnace uses producer gas containing, by volume, as it reaches the regenerators:

CO	26.97 per cent.
CO ²	4.37 "
CH ⁴	0.33 "
H ²	13.00 "
NH ³	0.21 "
H ² S	0.10 "
N ²	54.01 "
Air	1.03 "

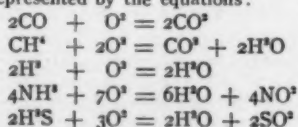
Each cubic meter, measured at 20° C. and 720 m.m. barometric pressure, is accompanied by 73.22 grams of moisture, as determined by drawing through a drying tube and weighing the moisture. The air used is at 20° C., 720 m.m. barometer, and three-quarters saturated with moisture. A maximum of 10 per cent more air is used than is theoretically necessary to completely burn the gas (assuming NH³ to burn to H²O and NO², and allowing for the air already present in the gas). The gas and air may be both assumed as coming to the regenerators at 20° C., and to be heated in the regenerators to 1200° C.

Required.—(1) The relative volumes of gas and air passing through the gas and air regenerators.

(2) The total amounts of heat necessary to be furnished to each, per cubic meter of gas used.

(3) The relative sizes of the two regenerators.

Solution.—(1) Taking 1 cubic meter of the dry gas, as represented by the analysis, the combustion of its combustible ingredients is represented by the equations:



And since molecules represent volumes, each unit volume of CO, CH⁴, H², NH³ and H²S is seen to require respectively 0.5, 2, 0.5, 1.75, or 1.5 volumes of oxygen. The 1 cubic meter of dry gas therefore requires oxygen as follows:

CO	0.2697	×	0.5	=	0.1349	m ³
CH ⁴	0.0437	×	2.0	=	0.0874	"
H ²	0.1300	×	0.5	=	0.0650	"
NH ³	0.0021	×	1.75	=	0.0037	"
H ² S	0.0010	×	1.5	=	0.0015	"

Total = 0.2925 "

Air needed = 0.2925 ÷ 0.208 = 1.4062 m³

Add 10 per cent excess = 1.5468 "

Air present in gas = 0.0103 "

Air to be supplied = 1.5365 "

Each cubic meter of dry gas, at any given conditions of temperature and pressure, would require 1.5365 cubic meters of dry air at the same conditions of temperature and pressure. This, however, is not exactly the relation required, for the reason that the gas is accompanied by considerable moisture, which in reality adds to its volume, while the air is also moist, adding to its volume. Two corrections must therefore be applied; first, to calculate the volume of the moisture accompanying 1 cubic meter of (assumed) dried gas; the second, to calculate the volume of moisture accompanying 1.5365 cubic meters of (assumed) dry air. Assuming our gas and moist air both at 20° and 720 m.m. pressure, the volume of moisture accompanying 1 cubic meter of (assumed) dry gas is the volume of 73.22 grams of moisture at these conditions, which is

$$73.22 \div 1000 \div 0.81 \times \frac{273 + 20}{273} \times \frac{760}{720} = 0.1024 \text{ m}^3$$

The air being 0.75 saturated with moisture at 20°, the tension of this moisture will be 17.4 × 0.75 = 13 m.m. The air proper is therefore under 720 - 13 = 707 m.m. tension instead of 720 m.m. and the volume of the moist air containing 1.5365 cubic meters of (assumed) dry air is therefore:

$$1.5365 \times \frac{720}{707} = 1.5648 \text{ cubic meters.}$$

The relative volumes of actual (moist) gas and actual (moist) air used are therefore:

$$1.1024 : 1.5648 = 1.0000 : 1.419 \quad (1)$$

(2) To calculate the heat necessary to raise gas and air from 20° to 1200° per cubic meter of gas used, the best preliminary is to calculate the composition of the gas, including its moisture. Since 1 cubic meter of (assumed) dry gas is accompanied by 0.1024 cubic meter of water vapor, the sum being 1.1024 cubic meters, we can calculate the real percentage composition to be:

CO	24.47 per cent.
CO ²	3.96 "
CH ⁴	0.30 "
H ²	11.79 "
NH ³	0.19 "
H ² S	0.09 "
N ²	48.99 "
Air	0.93 "
H ² O	9.29 "

Of the above quantities the (assumed) dry gas in 1 cubic meter of (actual) moist gas is 0.9071 c.m. The air used for its combustion will therefore be:

$$0.9071 \times 1.5365 = 1.3938 \text{ m}^3 \text{ dry air.}$$

$$0.9071 \times 1.5648 = 1.4080 \text{ m}^3 \text{ moist air.}$$

$$1.4080 - 1.3938 = 0.0142 \text{ m}^3 \text{ of moisture.}$$

The heat required by the 1 cubic meter of (actual) moist gas is found as follows:

$$\text{Volume} \times \frac{\text{Mean Specific Heat}}{20^\circ - 1200^\circ}$$

CO	0.2447	} × 0.3359 = 0.2895 Calories.
H ²	0.1179	
N ²	0.4899	
Air	0.0093	
CO ²	0.0396	× 0.6384 = 0.0253 "
H ² O	0.0929	× 0.5230 = 0.0486 "
CH ⁴	0.0030	× 0.6484 = 0.0019 "
NH ³	0.0019	× 0.5752 = 0.0011 "
H ² S	0.0009	× 0.5230 = 0.0005 "

Mean cal. capacity per 1° = 0.3669 "

Total calorific capacity 20° — 1200°

0.3669 × 1180 = 432.9 Calories.

The calorific capacity of the moist air simultaneously heated through the same range will be:

Air 1.3938 × 0.3359 = 0.4682 Calories.

H²O 0.0142 × 0.5230 = 0.0074 "

Sum = 0.4756 "

Total calorific capacity 20° — 1200°

0.4756 × 1180 = 561.2 Calories.

The air regenerator should therefore have $561.2 \div 432.9 = 1.30$ times the heating power or cross-section of the gas regenerator; i. e., 30 per cent more. Or the combined capacity of the pair of regenerators should be divided so as to give 57 per cent to the air regenerator and 43 per cent to the gas regenerator. In ordinary practice it is usual to allow about 60 and 40 per cent respectively; it is better to calculate ahead for the specific case in hand, if the composition of the gas to be used is known.

VALVES AND PORTS.

No very exact rule can be given as to the size of the gas and air valves, or those leading the products to the chimney. If made too large they are cumbersome to operate and apt to warp; if made too small they give undue obstruction to the flow of gas. A general rule is to calculate the free opening, such as to give the gases passing through a velocity between 3 and 5 meters (10 and 16 feet) per second, allowing, of course, for the average temperature of the gas or air or products of combustion passing through them. It may be remarked that while water-seal valves are very convenient, the water is evaporated where in contact with gas or air, and diminishes the heating efficiency of the furnace, the use of a non-volatile oil or a fine sand would appear preferable to water.

The ports are a very important part of the furnace, and may be designed in many different styles for various ways in which a furnace is to be worked. Their cross-section, however, can be calculated when we know the volume of gas or air leaving the regenerators and their temperature, or the volume of the products of combustion entering the regenerators and their temperature. They should be so designed that the velocity of the gases through them is not over 20 meters per second, while 10 meters per second is a better velocity to use. A long furnace can admit of higher velocities at the ports than a short one; but in any case the higher the velocity the farther complete combustion will occur from the ports, and if the velocity is too high for the length of the furnace combustion may even be continued in the opposite regenerators and less than the maximum occur in the furnace. This is a condition to be scrupulously avoided if possible.

Problem 67.

Producer gas of the following composition:

CO	24.47 per cent	NH ³	0.19 per cent
CO ²	3.96 "	N ²	48.99 "
CH ⁴	0.30 "	Air	0.93 "
H ²	11.79 "	H ² O	9.29 "
H ² S	0.09 "		

is burned with 1.408 times its volume of moist air (see Problem 66). The furnace treats 50 metric tons of steel in 12 hours, using 17.5 tons of coal in the producers, from which 15 tons of carbon pass into the gas. The gas and air pass out of the regenerators at 1200°, and the products of combustion (assumed complete) pass into the opposite regenerators at 1400°. Assume a maximum velocity of the hot gas and air as 10 meters per second, as they pass through the ports.

Required.—(1) The volume of gas and air at 20° C. and 720 m.m. barometer used by the furnace per second.

(2) The areas of the gas and air ports.

(3) The velocity of the products entering the opposite ports.

Solution.—(1) The carbon in 1 cubic meter of the gas at standard conditions is

CO 0.2447

CO² 0.0396

CH⁴ 0.0030

0.2873 × 0.54 = 0.1551 kg.

Gas used in 12 hours (standard conditions):

15,000 ÷ 0.1551 = 96,710 m³

Per second = 2.24 m³

Gas used at 20° C. and 720 m.m.:

$$2.24 \times \frac{273 + 20}{273} \times \frac{760}{720} = 2.53 \text{ m}^3 \text{ per second. (1)}$$

Air used (standard conditions):

2.24 × 1.408 = 3.15 m³

Air used at 20° C. and 720 m.m.:

2.53 × 1.408 = 3.56 m³ per second. (1)

(2) The volume of gas used per minute, as it issues from the ports at 1200°, is

$$2.24 \times \frac{1200 + 273}{273} \times \frac{760}{720} = 12.8 \text{ m}^3$$

$$\text{and of air } 3.15 \times \frac{760}{720} = 17.9 \text{ "}$$

and assuming a maximum velocity for each of 10 meters per second, the areas of the ports must be:

Gas ports..... 1.28 m²

Air ports..... 1.79 "

Sum 3.07 " (2)

(3) There is usually contraction when gases burn, the products having less volume than the gas and air used. Inspecting the equations of combustion of CO, CH⁴, H², H²S and NH³ given in Problem 66, we can construct the following table of relative volumes concerned and the ensuing contraction:

	CO	CH ⁴	H ²	H ² S	NH ³
Volume used.....	1.0	1.0	1.0	1.0	1.0
Oxygen used	0.5	2.0	0.5	1.5	1.75
Gases combining	1.5	3.0	1.5	2.5	2.75
Volume of products.....	1.0	3.0	1.0	2.0	2.5
Contraction	0.5	0.0	0.5	0.5	0.25

Using 1 cubic meter of producer gas the contraction resulting from its combustion with an excess of air is

CO 0.2447 × 0.5 = 0.12235 m³

CH⁴ = 0.00000 "

H² 0.1179 × 0.5 = 0.05895 "

H²S 0.0009 × 0.5 = 0.00045 "

NH³ 0.0019 × 0.25 = 0.00050 "

Total contraction = 0.1822 "

Since the volume of gas, plus air used, is 2.408 m³, the volume of the products, at standard conditions, is

2.408 — 0.182 = 2.226 m³

per cubic meter of gas used under standard conditions. The

volume of products per minute, at standard conditions, is, therefore,

$$2.226 \times 2.24 = 4.986 \text{ m}^3.$$

And at 1400° and 720 m.m. pressure:

$$4.986 \times \frac{1400 + 273}{273} \times \frac{760}{720} = 32.7 \text{ m}^3.$$

Since the sum of the area of gas and air ports is 2.91 m², the velocity of the products in these ports will be

$$32.7 \div 3.07 = 10.7 \text{ m. per second.} \quad (3)$$

In both the calculations of the size of the ports and the velocity of the products we have assumed the tension of the gas, air or products in the ports to be the prevailing atmospheric tension. This may or may not be exactly true, because the air or gas may be under a slightly less tension, being drawn into the furnace by the stack draft. If the pressure inside the furnace, with doors closed, is greater or less than atmospheric pressure, the tension of the gases in the entrance ports will be correspondingly greater or less than the atmospheric pressure, while the tension of the products will probably always be less than atmospheric pressure, because of the stack draft. Under ordinary conditions these corrections are too small to need to be taken into consideration.

LABORATORY OF FURNACE.

The laboratory consists of the open space enclosed between the hearth, sides, ends and roof. Its dimensions vary with the intended capacity of the furnace and the ideas of the designer. If a hearth is to contain, say, 50 tons of melted steel, which weighs some 7 tons per cubic meter (425 pounds per cubic foot), there will be contained in the furnace at one time 7 cubic meters, or 260 cubic feet of steel. The deeper this lies the more slowly it will be heated or oxidized by the flame, and therefore there is a limiting depth of, say, 50 centimeters, or 20 inches, which it is not advisable to exceed, while a more shallow bath will result in faster working. Assuming a depth of 40 centimeters (16 inches), the volume divided by the depth will give the area of the bath:

$$7 \div 0.4 = 17.5 \text{ square meters} \\ 260 \div 1.25 = 208 \text{ square feet.}$$

We can then either choose a convenient width, consistent with a practicable roof span, and derive the length, or choose a length and derive the width, or choose a certain ratio of length to width, and derive both. If the width is 3 meters the length must be 5.8; if the length is assumed 5 meters, the width is 3.5; if the ratio of length to width is 2 to 1, the length figures out 5.92 meters and the width 2.96. These dimensions are those of the bath of metal, and each should be increased by at least 1 meter to get the area of the hearth inside the walls, thus allowing 0.5 meter clear space all around the metal.

If a furnace is short it should be wide and the roof high, in order to give cross-sectional area and thus diminish the velocity of the gases over the hearth. The gases attain their maximum temperature in the laboratory, theoretically some 1700° to 1900°, and their velocity depends solely on the vertical cross-sectional area of the laboratory or body of the furnace. In Problem 67, for instance, about 5 cubic meters of products of combustion (measured at standard conditions) pass through the furnace per second. At 1800° this volume would be 38 cubic meters, and if the laboratory were 4.5 meters wide by 1.5 meters high above the level of bath, there would be 7.25 square meters of cross-section, and the velocity of the gases would be $38 \div 7.25 = 5.2$ meters per second. This would allow barely 1 second for the hot gases to pass over the bath, which would result in a low rate of heating and probable incomplete combustion, for the gas can only burn as it gets mixed with air, and it is hardly likely that 100 per cent of it would get mixed with air and consumed in 1

second. Such could only be attained by sub-division of the gas and air and very intimate mixture at the ports. Much of the economy undoubtedly attained by raising the roof of open-hearth furnaces is due to the slowing-up of the gas currents in the laboratory, though it is usually ascribed to avoidance of contact of flame and bath, increased heating by radiation, etc. In the writer's opinion the raising of the roof from 1 to 2 meters, let us say, thus doubling the vertical cross-sectional area, cutting in half the velocity of the gases through the furnace, and doubling the period in which they are able to combine, and to radiate or impart heat to the furnace walls and charge—is the principal reason for the increased economy observed.

An equally important improvement is lengthening the distance between ports. There is a limit to the width of the furnace, set by the practicable arch for the roof; there is also a limit to the height of roof, set by the increasing distance of the gases from the hearth; when both these factors have reached their maximum, further efficiency of utilization of the heat of combustion can only be secured, as far as the body of the furnace is concerned, by lengthening the hearth. There is no mechanical limit, and in every case the distance between the ports and the velocity of the gases should be such that complete combustion takes place in the furnace laboratory before the products pass into the regenerators.

Problem 68.

H. H. Campbell gives in the *Transactions* of the American Institute of Mining Engineers, 1890, analyses made at the Pennsylvania Steel Co.'s works, as follows:

	Gas Burned, Entering Furnace.	Products, Leaving Furnace.
CO ^s	5.5 per cent.	3.1 per cent.
O ^s	2.3 "	0.7 "
CO	8.2 "	7.1 "
CH ⁴	7.3 "	0.0 "
H ^s	39.8 "	11.6 "
N ^s	36.9 "	77.5 "

Required.—(1) The proportion of the calorific power of the fuel developed while passing through the body of the furnace.

(2) The proportion of the air necessary for complete combustion which was used.

Solution.—(1) One cubic meter of the gas contains the following weight of carbon:

$$(0.055 + 0.082 + 0.073) \times 0.54 = 0.1134 \text{ kg.}$$

One cubic meter of products contains:

$$(0.071 + 0.031) \times 0.54 = 0.0551 \text{ kg.}$$

Therefore, volume of products per 1 cubic meter of gas:

$$0.1134 \div 0.0551 = 2.06 \text{ m}^3.$$

Calorific power of 1 cubic meter of gas:

CO	0.082 × 3062 =	251 Calories.
CH ⁴	0.073 × 8623 =	629 "
H ^s	0.398 × 2613 =	1040 "
		1920 "

Calorific power of 2.06 cubic meters of products:

CO	0.071 × 3062 =	217 Calories.
H ^s	0.116 × 2613 =	303 "
		520 "
	520 × 2.06 =	1071 "

Heat developed in the furnace:

$$1920 - 1071 = 849 \text{ Calories.}$$

Proportion of the possible heat development:

$$849 \div 1920 = 0.442 = 44.2 \text{ per cent.} \quad (1)$$

(2) The 1 cubic meter of gas needed, to burn its combustible constituents, the following amount of oxygen:

CO	$0.082 \times 0.5 = 0.041 \text{ m}^3$
CH ⁴	$0.073 \times 2.0 = 0.146 \text{ "}$
H ²	$0.398 \times 0.5 = 0.199 \text{ "}$

Sum = 0.386 "
Oxygen present in gas = 0.023 "

Oxygen needed from air = 0.363 "
Air = $0.363 \div 0.208 = 1.745 \text{ "}$

The 2.06 m³ of products of incomplete combustion require for their combustion:

CO	$0.071 \times 2.06 \times 0.5 = 0.0731 \text{ m}^3 \text{ oxygen.}$
H ²	$0.116 \times 2.06 \times 0.5 = 0.1195 \text{ " "}$

Sum = 0.1926 "
Oxygen present in the products = 0.0070 "

Oxygen needed from the air = 0.1856 "

Air needed to complete combustion = 0.892 "

Total air needed for complete combustion = 1.745 "

Air supplied in the furnace = 0.853 "

Percentage supplied:

$$0.853 \div 1.745 = 0.489 = 48.9 \text{ per cent.} \quad (2)$$

It is almost needless to remark that with less than half the air necessary for complete combustion supplied, a high calorific intensity of flame and a high utilization of the calorific power of the fuel are impossible. More air should have been used and the furnace made longer, so as to secure perfect combustion in the furnace, and not have over half the possible development left to take place in the regenerators or stack.

CHIMNEY FLUES AND CHIMNEY.

The gases pass into the chimney flues at from 150° to 450°. If their volume at an assumed average temperature of, say, 300° is calculated, they can be given an assumed velocity of 2 to 3 meters (5 to 10 feet) per second, and thus a suitable cross-sectional area of the chimney flues obtained. The stack will work best with a velocity of 5 meters per second, and thus its cross-sectional area may be calculated. A height of 25 to 30 meters (75 to 100 feet) is sufficient for most furnaces.

MISCELLANEOUS.

Some other data useful in figuring up the dimensions and running conditions of modern open-hearth steel furnaces are the following, taken mostly from an article by H. D. Hess, in the *Proceedings Engineering Club of Philadelphia*, January, 1904:

Average coal consumption, in pounds per hour per ton of metal capacity of the furnace, 55 to 80.

Cubical feet of space in one pair of regenerators, per ton of metal capacity of the furnace, 30 to 75.

Cubic feet of space in one pair of regenerators per pound of coal consumed per hour, 0.5 to 1.0.

A correlation and combination of data of this sort, with details as to the actual working of the furnaces, would point the way towards a general solution, which would furnish the best conditions for every possible case, with strict consideration for all the variables involved.

[The next instalment of these calculations will discuss the thermal efficiency of regenerators and of the furnace as a whole, also special forms of open-hearth furnaces worked in special ways.]

Melting Points of Elements.

Mr. James Swinburne, the distinguished British electrical engineer, recently presented a paper on new electric incandescent lamps before the (British) Institution of Electrical Engineers. The subject was discussed in an able manner from the physicochemical standpoint as to the materials which may be considered to be available for filaments, and special attention was naturally paid to melting points. Mr. Swinburne pointed out the regrettable lack of exact data available at present for many materials.

In the discussion, Dr. J. A. Harker, of the (British) National Physical Laboratory, presented the table, reproduced below, giving the melting points of the elements in degrees C., arranged according to the periodic law. Dr. Harker has carried out extended researches on this matter.

Only within the last six years has our scale of high temperatures been at all defined, and in Dr. Harker's opinion there is still great uncertainty attached to the higher temperature measurements made by optical methods. In the work at the National Physical Laboratory they have endeavored to get a kind of "bench mark" for use in the preliminary mapping out of the really high-temperature region (above, say, 1,500° C.) by making a new determination of the melting point of platinum. Dr. Harker stated that the value found for the platinum point was 1,710° C.; i. e., 70° lower than the old accepted value of Violle, depending on the determination made, twenty years ago. The new lower value has been confirmed in Germany.

Some of the data on the table are taken direct from the papers of the various authors. To others corrections have been applied, when it has been possible to revise the standard points on which they depend, and others, again, are new determinations made at the National Physical Laboratory. Boron and carbon at ordinary pressures do not melt before volatilizing. In group four, titanium melts in the region of 2,500°, but zirconium is quite low, 1,300° C., cerium still lower, while for thorium, whose melting point is undoubtedly very high, no record of any determination has been found. The data in the eighth group are many of them very uncertain. Iridium, which melts above 2,000° C., gives off a great deal of vapor far below this temperature.

Dr. Harker's table, which we give below, is reprinted from the account of the discussion of Mr. Swinburne's paper in *The Electrician* (London), Jan. 18.

	I.	II.	III.	IV.	V.	VI.	VII.	VIII.	IX.
1	Li -99.9	Ba under 1,000	B	C	N -315	O 285	P 233		Ne
2	Na 98	Mg 680	Al 937	Si 1,410	P 44	S 114	Cl -103		Ar
3	K 99	Ca 780	Sc 1,540	Ti 2,500	V 1,890	Cr 1,800	Mn 1,300	Fe 1,530 Co 1,530 Ni 1,457 Cu 1,354	
4	Rb 39	Sr 900	Y 1,400	Zr 1,800	Nb 1,600	Mo 2,600	Br 7		Kr
5	Cs 28	Ag 963	Cu 1,084	In 174	Sn 224	Pb 327	Tl 304		Xe
6									
7									
8									
9									
10									
11									
12									

TABLE OF MELTING POINTS.

Charles Frederick Chandler

"A great name shall never pass away." Rich in that accumulated knowledge which we call wisdom, and especially so in that branch of knowledge which has for its purpose the improvement of the arts and industries, is Charles Frederick Chandler, who is easily the foremost authority in the United States on industrial chemistry. Gladly we yield space for a brief sketch of his career.

Chandler was born in Lancaster, Mass., on December 6, 1836, and received his early education in New Bedford. As a boy, he came under the influence of that great teacher of science—Louis Agassiz—and in time he entered the Lawrence Scientific School of Harvard, where he studied geology under Agassiz, and chemistry under Horsford. Choosing chemistry as his specialty, he went abroad, spending two years first at Göttingen, where he followed his favorite study under Wöhler, and then at Berlin, where he assisted Heinrich Rose.

In 1856 he returned to the United States and soon was called to the chemical department of Union College, in Schenectady, where even before he attained his majority he succeeded to the duties of the full professorship. Here he remained for eight years, unfolding the fascinating wonders of chemistry to ever-increasing classes of students.

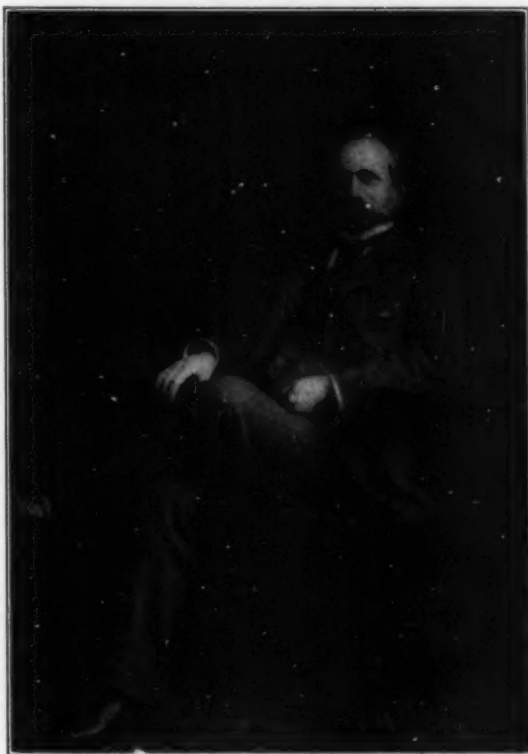
The rapid development of the natural resources of our country clearly indicated the necessity of some means for providing properly equipped experts to take charge of the many industrial works that were rapidly coming into existence for the conversion of the crude products of the soil and forest into the finished articles of commerce, and so half a century ago technical schools were created from which soon were graduated chemists, mining engineers, metallurgists, and the like.

One of the first of these institutions was the science department of Columbia University, which began its life in 1864 as the School of Mines of Columbia College. The project and plan of this school originated with Thomas Egleston, a graduate of Yale and the Ecole des Mines of Paris, who took the chair of mineralogy and metallurgy. Gen. Francis L. Vinton, a graduate of West Point and the Ecole des Mines, took the chair of civil and mining engineering, and Chandler took the chair of chemistry. The school opened Nov. 15, 1864, with twenty-four students, the number increasing to forty-seven during the first session.

Full of enthusiasm at the opportunity and strong with his love for chemistry and for teaching, he organized the department and taught his chosen science and geology. He builded so wisely that to-day, forty-three years later, as Mitchell professor of chemistry in Columbia University, his name stands first at the head of twenty associates in the chemical department, most of whom studied under him, and all of whom are proud to call him master.

There was much work for him in those early days, for soon

the College of Pharmacy sought and obtained his services, and the College of Physicians and Surgeons claimed a share of his time, and so he was a potent factor in the increase and diffusion of a knowledge of chemistry. And yet there is more. He became chemist to the Metropolitan Board of Health, and milk was purified, illuminating oil made non-explosive, the water supply freed from contamination, the adulteration of food checked, and other sanitary reforms made, until it seemed as if chemistry under Chandler's hands was the magic wand by which all things were made pure and healthful. His splendid work led to his appointment in 1873 to the presidency of the Board of Health, and when, in 1884, he retired from office, the statement, "There is no other city in the world which has so complete a sanitary organization as New York," was published as a parting benison in worthy recognition of his arduous labors for the benefit of humanity.



C. F. Chandler

In 1870, with his brother, the late William H. Chandler, professor of chemistry in Lehigh University, he established *The American Chemist*, a monthly journal devoted to chemical science. In addition to this, he wrote a series of articles on technical chemistry—"the best in the English language"—for Johnson's Universal Cyclopedia, and the university and the students profited thereby, for it led to the forming of the only museum of raw materials and products connected with chemistry in this country.

Then there were public lectures before the American Institute, the Academy of Sciences, and other similar organizations, to which many came, for Chandler has no superior in the art of lucidly describing things technical, and always holds the attention of his audiences, whether students or jury. A word must be added of his success as an expert in court. His testimony seldom fails to carry conviction. He tells the whole truth, and the verdict is his because he is right.

His fellow workers in science have often shown their appreciation of his ability. In 1874 he was elected a member

of the National Academy of Sciences, and to him that body has entrusted important governmental commissions, notably the one on the best means of preserving the writing on the Declaration of Independence. In 1874 also he presided at the centennial celebration of the discovery of oxygen held in Northumberland, Pa., where Priestly, the father of modern chemistry, lies buried. Twice he has been president of the American Chemical Society, and in 1889 he was chosen president of the English Society of Chemical Industry, being the first American to receive that honor.

His contributions to sanitary science were recognized by the honorary conferment of the degree of M.D. by the University of New York in 1873; in the same year Union, where he first taught, enrolled him among her honorary alumni by giving him her highest doctorate, that of Laws, and finally Oxford, in 1900, crowned him with the well-merited degree of Doctor of Science. His last honor came only a few months ago.

The University of Göttingen, where he received his degree of Doctor of Philosophy in 1856, sent him a new diploma in recognition of his fifty years of active work in chemistry.

Thus has his life been spent, and now, at the age of three-score-and-ten, his ever-youthful enthusiasm finds interest in new projects for the advancement of chemistry. Among these may be mentioned an ambition to secure an endowment for the Chemists' Club, of New York, of sufficient size to permit the securing of a library in duplicate, so that, in addition to the series of books retained at home for reference, chemists throughout the country may borrow from the consulting department the entire literature of any subject for a definite period of time.

In the mines of South Africa, in the universities of far-away Japan, and all the way between are busy workers in science, who have learned their art from Chandler, and all of whom sincerely hope that long years of health and activity may yet be his.

MARCUS BENJAMIN.

[A few additional words may be said as to Prof. Chandler's intimate connection with the special field of electrochemistry. Dr. Chandler was one of the earliest students in America of electrochemistry. He acted as expert in the suits brought by Isaac Adams to secure his rights to the invention of nickel plating; acted as expert for Mr. Thomas A. Edison in connection with his electric soldering of lamp filaments and his famous feeder case; was expert in many of the important storage battery cases; acted for the Pittsburg Reduction Co. in defending the Hall aluminium patents, and for Mr. Acheson in defending his carborundum inventions; for the Carbide Co. in its interference case; for Hamilton Y. Castner in connection with his processes for manufacturing sodium, peroxide of sodium, cyanides, caustic soda and chlorine, and more recently acted as expert in the zinc plating litigation.—EDITOR.]

Bleaching Liquors.

At the Bavarian Jubilee Exhibition in Nuremberg, in 1906, an electrolytic plant for producing hypochlorites, according to the patents of Schoop, was shown in operation. It is described by A. Hundt in *Elektrotechnische Zeitschrift*, Dec. 27. Figs. 1 to 3 show the arrangement.

The electrolyzer E consists of ten shallow hard-rubber

boxes, which are placed in pairs of two on a stairway of five steps. The boxes are divided by means of insulating walls into a number of channels, about 1.5 cm. broad through which a 10 per cent solution of sodium chloride is passed.

The solution passes from the distributing vessel G into the upper boxes and flows gradually downwards and from the lowest ones into the concrete tank Z. While the salt solution is run in that way through the boxes, it is electrolyzed. For this purpose the boxes are provided with electrodes which connect the different channels with each other and with the terminals for the supply current, as shown in Fig. 2.

In order to get a high concentration of bleaching liquor the electrolyte is passed several times through the boxes. The pump C lifts the solution from the tank Z back into the vessel G, from where it passes again through the boxes. At the same time, the solution is cooled artificially by means of the cooling coil Sch. from the cold-water reservoir W.

When the electrolysis is completed, the valve V is turned and the liquor passes into the storage tank B. It is then diluted with eight or ten times its volume of water before it can be used for bleaching.

The operation is as follows: The solution of sodium

chloride is prepared in the solution tank L, and is then passed into the settling tanks M N, and from there, after the spigots K and J have been opened, it is lifted with the pump C into the tank G, from whence it flows through the boxes E into a tank Z. As soon as the latter is filled, the spigot H is opened



FIG. 2.—ELECTROLYTIC BOXES.

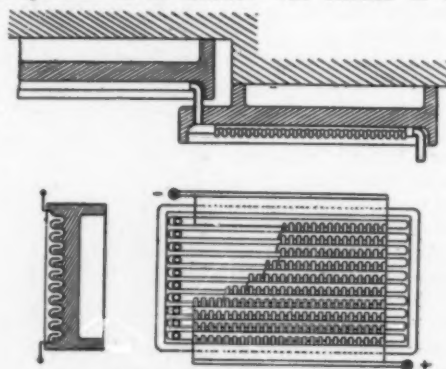


FIG. 3.—ARRANGEMENT OF ELECTRODES IN ELECTROLYZER.

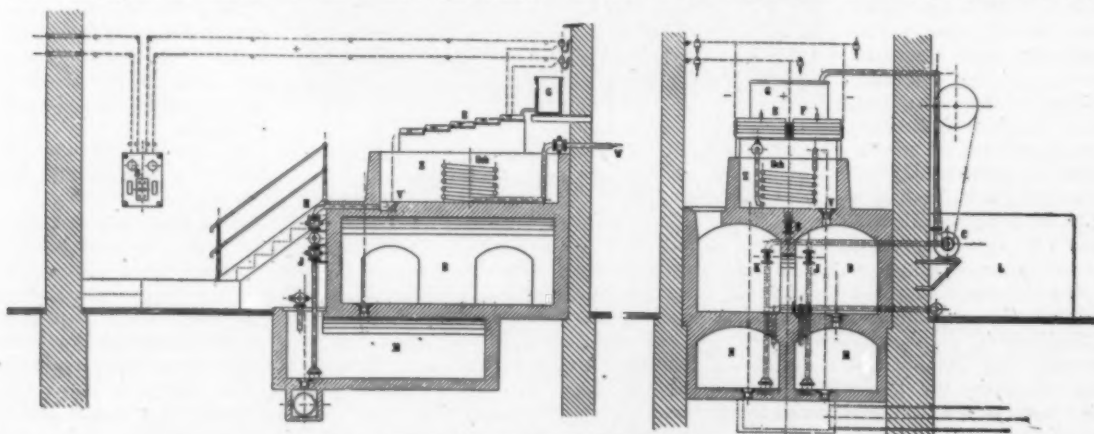


FIG. 1.—GENERAL ARRANGEMENT OF HYPOCHLORITE PLANT.

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current, but is more expensive and is more sensitive with respect to variations of temperature, since the temperature of the electrolyte must be maintained constant at 15° C., while with the second and considerably less expensive arrangement, the temperature may rise to 25° C. The apparatus produces about 0.2 kg. of bleaching chlorine per kw.-hour, with a consumption of about 1.25 kg. of common salt. Electrolytic bleaching liquor can be stored for several days without losing its bleaching activity.

Nitrogen in Iron.

Hjalmar Braune furnishes us with the most exhaustive treatise on this subject yet published. His original article of over a hundred pages in the *Swedish Iron Society Journal* is condensed to some eighteen pages of *Stahl und Eisen*, in the numbers of Nov. 15, Dec. 1 and Dec. 15, last. The circumstances leading to Braune's investigations are thus narrated in the first paragraphs of his article. During the last decade of the last century, many Swedish blast furnaces sent pig iron to England which was complained of, because the wrought iron produced from it was brittle at orange heat. The analysis of this iron showed no variation from previous good-quality iron, and the cause of the trouble was a mystery. The most various theories were proposed to explain the reason for these difficulties. In 1900 and 1901, Braune commenced a systematic examination of a large number of Swedish blast furnaces, from which it was learned that the bad iron was produced whenever a certain limit of temperature was surpassed in the smelting zone of the furnace, and basic slag was produced. Under these circumstances, potassium cyanide is formed in the furnace and poor iron results; from which it was concluded that the absorption of nitrogen from this cyanide, by the pig iron, was the primary cause of the subsequent troubles. In 1903 Braune began to investigate various kinds of iron and steel in the most various ways, in order to determine whether the explanation offered was correct. The result of this research was to show that iron takes up nitrogen not only in the blast furnace, under the conditions mentioned, but also in any metallurgical process wherein nitrogen and carbon have opportunity to act on iron at a high heat and in the presence of a basic slag, and that the resultant product has its properties profoundly modified by this absorption. These researches were carried out in the University laboratory at Basel, in the Testing Bureau at Zurich, and at the College des Mines in Paris.

The first point of attack was to determine the condition in which nitrogen exists in iron. Since hydrochloric acid dissolves iron without evolving cyanogen gas, or hydrocyanic acid gas, it was concluded that the nitrogen in commercial forms of iron is not present as iron cyanide or as any cyanide compound. Experiments showed that on solution in hydrochloric or sulphuric acids, no free nitrogen is evolved but that all the nitrogen in the iron is converted into chloride or sulphate of ammonium; the conclusion is that the nitrogen is present in the iron as a nitride, probably Fe_3N_2 . It is true that cyanogen or hydrocyanic acid gas is given off when iron is dissolved in nitric acid, but this does not prove that nitrogen exists in the iron as a cyanide, because perfectly pure iron carbide containing no nitrogen acts in the same way, showing the nitrogen in the cyanogen to come from the nitric acid used. Incidental to this test, Braune showed that Eggert's carbon color test is not influenced or rendered inaccurate by the presence of nitrogen in the steel in various amounts.

Braune next prepared specimens of iron and steel with varying amounts of nitrogen, but otherwise of constant composition. The specimens were heated in a porcelain tube to 600° to 800° and dry ammonia gas passed over them. After this treatment, the nitrification is greatest on the outside, just like cementation or case-hardening; to render the distribution of nitrogen uniform the pieces were packed in sand in a sheet-iron case and annealed. By repeating these operations, speci-

mens were made containing as high as 7 per cent of nitrogen, uniformly distributed. In general, the per cent of nitrogen cannot be inferred from the fracture of the material, but chilled cast iron forms an exception. In ordinary chilled pieces, the boundary between grey and white is sharp, and if blow-holes are present, they are in the white part, with rounded sides; as the nitrogen content increases, the boundary between the two colors becomes less and less distinct, white patches become common in the grey part, and *vice versa*, and small gas cavities appear in the grey part, with sharp corners. Braune could not determine any characteristic change caused by small amounts of nitrogen in the appearance of either white, grey, or puddled iron. But 0.03 to 0.045 per cent of nitrogen will cause the small gas cavities referred to in white iron, and enough nitrogen to cause bitterness will give a crystalline fracture, with bright reflections, to soft iron.

To test the mechanical properties of iron containing nitrogen, soft wrought iron containing 0.06 per cent carbon, 0.01 silicon, 0.06 manganese, 0.05 phosphorus and 0.005 sulphur was nitrated until it contained 0.015 to 0.120 per cent of nitrogen. The tensile strength is found to increase 0.035 kg. per square millimeter (50 pounds per square inch) for each 0.001 per cent increase in nitrogen, and the extension before fracture to decrease about 0.1 per cent for each 0.001 per cent of nitrogen. Specimens containing less than 0.60 nitrogen could be forged and welded easily, but with greater amounts showed brittleness, hot and cold.

Steel containing 1.15 per cent carbon, 0.20 silicon, 0.45 manganese, 0.025 phosphorus and 0.012 sulphur was next treated similarly, with surprisingly different results. The tensile strength increases slightly and elasticity decreases regularly to 0.035 per cent of nitrogen, at about the same rate as for wrought iron. Just above this point, however, the tensile strength fell off suddenly 6.2 kg. per sq. m. (9,000 lbs. per sq. inch), while the elasticity fell at one stroke from 16 per cent down to 2 per cent. Similar tests on best high-carbon steel and soft girder steel showed again the danger line for nitrogen to be 0.035 per cent, above which brittleness and loss of forging qualities occur. Hardening cracks in steel occur plentifully when nitrogen is above 0.02 per cent. Hardened steels are more sensitive to the effect of nitrogen than unhardened.

The electrical resistance of soft iron wire is increased by the presence of nitrogen, 0.267 per cent of nitrogen increasing the resistance 16 per cent, or lowering the conductivity 14 per cent, while the wire is made also less tough. Telephone and telegraph wires should therefore contain as little nitrogen as possible. The magnetic qualities of soft iron are also greatly altered by nitrogen, which acts similarly to carbon, decreasing the magnetic saturation capacity and increasing permanent magnetism. Sheet iron for transformers should be as low as possible in nitrogen, since the bad effects are much greater than when used as magnet cores.

The metallographic examination of iron containing nitrogen showed a change from amorphous to crystalline structure as nitrogen increased, depending on the content of carbon, intermingled slag and the working of the piece. Nitrogen causes the development of the Neuman lines, such as are seen in meteorites, which latter also contain large amounts of nitrogen. At 0.040 per cent nitrogen, where the sudden drop in extensibility occurs, a new microscopic structure occurs, consisting of a quantity of rings looking like craters, uniformly disseminated over the grains of ferrite. The rings are iron nitride and the background cementite. As nitrogen increases, these craters become more numerous, and at 0.150 per cent run into finger-shaped markings.

An investigation of many samples of commercial wrought iron and steel from all over the world showed 0.062 per cent of nitrogen as the highest and 0.02 per cent as the lowest. Grey pig iron is generally nearly free from nitrogen, coke iron of this class showing 0.007 to 0.009 per cent, but in a few

Swedish furnaces up to 0.020. White pig iron usually contains much more, especially in coke iron; in iron for Bessemer use, Braune found 0.02 to 0.03 per cent, for basic open-hearth 0.025 to 0.35 per cent, iron for puddling 0.03 to 0.035 per cent. Exception to these figures is some Swedish white iron, which runs only 0.003 to 0.020 per cent. "Washed" pig iron from different countries showed unusually high nitrogen, varying between 0.035 and 0.050 per cent, which often results in the production of crucible steels brittle because of nitrogen. Good basic steel contains usually 0.020 to 0.025 per cent of nitrogen, occasionally as much as 0.030 to 0.35. Swedish crucible steel is very low, 0.006 to 0.020 per cent at the most. Electric furnace steel made by resistance heating is practically free from nitrogen, but when made by arc heating, in presence of a basic slag, may contain much nitrogen and even injurious amounts.

Braune concludes by stating that the complete ignoring of nitrogen as a factor in commercial iron and steel is no longer possible, and that it should have a place in specifications, about, for instance, as follows:

	Nitrogen.
Beams, ship plates of wrought iron or soft steel,	
under	0.030 per cent
Rails of medium hard steel, under.....	0.025 "
Railway springs, tools of hard steel, under.....	0.012 "
Cannons, parts of rifles, under.....	0.008 "

Such specifications can be readily lived up to by the present methods of manufacture, if care is taken, particularly as to the nitrogen content of the raw material used.

JOS. W. RICHARDS.

Faraday Society.

The twenty-fifth meeting of the Faraday Society was held on Jan. 15, Past President Sir Joseph Swan being in the chair.

ELECTRON THEORY AND ELECTROLYSIS.

Mr. E. E. FOURNIER D'ALBE read a paper and opened a general discussion on "The Application of the Electron Theory to Electrolysis."

The electron theory by postulating the existence of material carriers of all electric charges, is practically an extension of the ionic theory to solids and gases, and it thus brings into line the processes of metallic and electrolytic conduction. In both cases the conductivity of a body is defined by the number of ions (in the wide sense) it contains in unit volume and by their average mobility; in a cm.-cube of copper, for example, a current is conveyed by some four hundred trillion free electrons, in a cm.-cube of milli-normal hydrochloric acid the current is conveyed by some two trillion hydrogen and chlorine ions. In a 1-mm. copper wire carrying 1 amp. the electrons will move at about 1 cm. per second.

It is not yet clearly understood why free electrons should be observed in a vacuum and a metal, but that there should be none in a liquid. It is supposed, however, that it is the close packing of the metallic atoms which renders possible a frequent exchange of electrons between one atom and another, and while free the electron is able to fall along the potential gradient and thus constitute a current. In an insulator the electrons are effectively bound up with the atoms or molecular groups; in an electrolyte mobile charged groups are formed, which can follow the e. m. f. Free electrons are not formed on account of the unequal attractions for these displayed by the positive and negative atoms of the solute. Thus in an HCl solution, when two atoms of a molecule separate, the hydrogen atom will lose an electron and become positively charged, while the chlorine atom will gain one and become negatively charged. These ions will act as condensation nuclei, gathering molecules of the solvent around them and becoming "hydrated." The expenditure of energy involved facilitates the condensation, which explains the low mobility of the ions and

the variability of the same, the drop of potential at the electrodes, and the liberation of uncharged products. The e. m. f. is unable to drive the hydrated ions into the closely packed atoms of the electrodes, but if it exceeds a certain minimum it is able to drive electrons in or out, as the case may be, and the constituent elements of the ions then lose their condensing powers, drop the water molecules, and are thus liberated as uncharged atoms.

The author draws attention to the importance of making further studies of mobility and quantitative determinations of the hydration of ions as a preliminary for determining the sizes of the ions and of their actual constitutions based on kinetic principles. It is possible that the motions of heavy ions may be actually observed in an ultra-microscope. The future development of electrolytic theory will lie, in the author's opinion, in the direction of statistical analysis of these motions of the ions through the electrolyte and into the electrodes, after the fashion of Thomson's "counting experiment," and in the complete determination of the energy transformations at each stage.

Mr. John G. A. Rhodin considered that the electron theory, like the atomic theory, merely complicated matters, and was unnecessary. The conception of infinite divisibility was a necessary one in physics as in mathematics, if our reason was to be satisfied. Both in chemistry and physics we know of mathematical relations only, and hypothesis are only crude images. The ether and electrons were invented because certain phenomena could be the more easily treated mathematically by means of these conceptions. A simple theory of ions was all that was necessary for understanding electrolysis; more hypotheses were not wanted. Existing theories left many well-known facts without explanation. He suggested the appointment of an international committee for generalizing existing theories and making them available to the average intelligence.

Dr. H. Borns asked whether the Hall effect and the recent experiments of Kaufmann did not throw some doubt on the electron theory. Why were there no free electrons in liquids?

Dr. J. A. Harker was not clear as to whether the theory supposed atoms to be composed entirely of electrons or whether there were a central nucleus. If the former, one would expect more intermediate formations. He thought the fundamental conceptions of the theory should be made perfectly clear, so that the explanations of various phenomena given by it could be deduced from some simple postulates.

Dr. T. M. Lowry pointed out that much of the work on hydration asked for by the author had been carried out, among others, by Blitz, Jones and Bousfield. The latter had shown, for example, that the chlorine ion attracted five water molecules to itself.

Mr. N. T. M. Wilsmore considered that the theory, which looked upon electrons as exerting a sort of osmotic pressure at the surface of an electrode, conceived admirably the mechanism of electrode potential and of electrode reactions. It was noteworthy that the more electro-positive a metal, the more easily it threw off electrons under the stimulus of ultra-violet light, for example. He showed how the theory explained, in a simple manner, oxidation and reduction phenomena and the action on the positive accumulator plate. He thought that the negative electron should have a distinctive name, and proposed using the word "negatron," which had been suggested.

Mr. F. Kaye remarked on the simple explanation of the different mobilities and, therefore, hydrations of the various ions on the view that the positive and negative ions acted to different degrees as condensation nuclei. He asked whether when a liquid was evaporated there was a movement of electrons into the vapor.

Mr. F. S. Spiers pointed out that the theory did not seem to help in explaining the fundamental preliminary to electrolysis, namely, dissociation in solution.

Mr. E. E. Fournier d'Albe replied to the various speakers.

He did not think that the few considerations put forward by Mr. Rhodin overthrew the theory. The difficulty of the Hall effect mentioned by Dr. Borns was more serious, but the negative swing that had been observed might be due to positive ions of great mobility, and not necessarily to the existence of positive electrons. A similar recent observation of the Faraday effect could be similarly explained. Kaufmann's experiments dealt with structure of electrons and merely pointed to Abraham's theory of a rigid electron being more probable than Lorentz's, which, in order to account for the Michelson-Morley experiments, supposed the electron to become shortened in its passage through the ether. Their great mobility in face of little resistance would prevent free electrons existing in liquids. When a metal was liquified, probably polymerization took place, and ions were formed which carried the current.

In reply to Dr. Harker, it seemed that atoms most likely consisted of negative electrons whirling round a positive nucleus. The solar system presented a close analogy. Only certain configurations would be stable, hence every intermediate stage of element would not persist. The theory at present could not be built up from simple postulates; it was in the induction stage, and kept in close contact with facts.

In reply to Mr. Kaye, electrons did not pass into the vapor from a boiling liquid; the surface of the liquid was a perfect semi-permeable membrane.

Notes on Electrochemistry and Metallurgy in Great Britain.

(From Our Special Correspondent.)

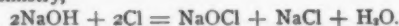
HYPOCHLORITES AND THE SAFEGUARDING OF WATER SUPPLIES.

Close upon the first meeting of the Faraday Society (to which I referred in my last letter as notable as being given up to hypochlorites), there followed a meeting of the Society of Engineers in which the atmosphere was similarly chlorous. The paper, which was by Mr. W. Pollard Digby and Mr. C. H. Shenton, was entitled "The Bacterial Contamination of Streams and Oyster Beds." It may be divided into four sections: (a) the need of sterilization as advanced by the reports of various Royal Commissions, (b) means of sterilization, chlorine in the form of hypochlorite being recommended, (c) a history of the application of hypochlorite processes, with notes on various patents, and theories as to the reactions taking place during electrolysis, (d) and the cost of application and its relative apportionment between the sewage and other authorities.

A 90 minutes' discussion followed, mainly of a bacteriological nature. On the electrochemical side, various speakers (Mr. C. V. Biggs, Mr. E. F. Pollard, Mr. E. C. Thrupp and Dr. F. W. Alexander), dealt with such points as stability, and the substitution of graphite for platinum in the construction of the anodes.

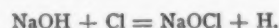
It may perhaps be mentioned that this paper gives the first public description of the new Digby electrolyzer. The particular feature of this apparatus consists in the manner in which the re-combination of the anode and cathode products is secured. In place of the re-combination taking place in the main body of the electrolyte, it can only take place in the special porous compartment closely enclosing the electrodes. The re-combination may take place in either the anode or in the cathode compartment, the products of the one, compartment being conveyed to the other compartment. Thus the caustic hydrate from the cathode cell flows by gravity into the anode compartment, the two compartments being connected by a glass pipe. Fresh water, or water containing an excess of alkali, is run into the cathode cell. This process gives hypochlorite solutions of low saline content, the only salt present in the resultant liquor being that due to diffusion depending upon the porosity of the closely covering compartment walls.

As to the ultimate reaction between the sodium hydrate formed at the cathode, the authors referred to that given in Mr. J. B. C. Kershaw's recent article in *ELECTROCHEMICAL AND METALLURGICAL INDUSTRY*, and quoted one more generally accepted, and given by Mr. Bertram Blount in his "Practical Chemistry,"



This explanation accords with that favored by Professor Ostwald, in Part 2 of his "Conversations on Chemistry," in describing the formation of sodium hypochlorite by chemical means.

They also offered for consideration the view for a long time privately held, and now publicly advanced for the first time, by Mr. W. Pollard Digby, that for low strengths the reaction is



The reasons for favoring this most simple hypothesis are two-fold, being, firstly, the large number of authenticated cases in which the electrochemical efficiency of production has not been 50 per cent or under, as would agree with either the Kershaw or Blount hypothesis, but upwards of 80 and 90 per cent, which would agree more clearly with the simplest hypothesis described; and, secondly, the fact that when the re-combination does take place under special control, there is a gaseous evolution on the mixture of the anodic and cathodic products. The character of this gaseous evolution has not (up to the time of writing) been determined, but attention is being given to the matter. For high strength solutions, and in cases where the current efficiency is 50 per cent or less, the Blount and Ostwald explanation should be accepted. It seems, however, scarcely tenable where it can be proved that the current efficiency is 70 per cent or higher.

PRESIDENTIAL ADDRESSES AND ELECTROCHEMISTRY.

It has been my custom on two previous occasions to use the above heading as an introduction to my notes on any subject matter of an electrochemical or electrometallurgical nature in the presidential addresses delivered to the various engineering and scientific societies in London or in the provinces. I have heard several such addresses, and read more. But, in striking contrast with previous years, I find an utter dearth of reference. Even the high price has not led any president of the institution of Electrical Engineers to allude to the value of aluminium, and the manner in which the British Aluminium Co. are pushing ahead with their Loch Leven scheme.

One note is frequently reiterated, and that is the valuable services rendered to the metallurgical industries by the simplicities ordained by the Engineering Standards Committee. Another matter frequently referred to was the advent of the metallic filament glow lamp. Nothing new was said upon either subject.

I must, however, mention Dr. Charles Drysdale's address to the students of the I. E. E. upon the "Electrical Industry at Home and Abroad." Not for its direct electrochemical or its electrometallurgical interest, but for its plea for the wider culture, which is so often lost sight of in our colleges, Dr. Drysdale's advice was, "Study ethics, economics and hygiene. Remember that you are a human being first, and an engineer afterwards. The works of Adam Smith, Ricardo, Bentham, Bain, Malthus, J. S. Mill and William Ellis are mines of almost unexplored wealth, and should enable you to avoid very many pit-falls. After you may have read these you may try Henry George and Karl Marx, in order to know what labor is being fed on. Had I my way, a course on these subjects, as well as in commercial matters, should be an essential feature of every engineering college training, even at the cost of leaving some technical work out * * * * There are two ways of attempting to raise oneself above one's fellow creatures. One is by pulling yourself up, the other by pushing them down."

Surely it was pure inadvertence that the works of Herbert

Spencer were omitted from this index of commended literature.

THE METALLURGIST AND ELECTRICAL PROGRESS.

Mr. Hadfield's speech at the annual dinner of the Institution of Electrical Engineers paid tribute to the good work done at the National Physical Laboratory, and passed on to deal with the intimate relations between further electric progress and metallurgy. The metallurgist could offer a special steel with a lower hysteresis constant than pure iron, or a special steel with twelve times the resistance of ordinary iron. It was never safe to prophesy, but it was not inconceivable that some day the metallurgist might give them an alloy of iron comparable with copper in its conductivity.

THE FARADAY SOCIETY MEETING.

It is a great pity that the attendance at the meetings of scientific societies is not always commensurate with the intrinsic value of the papers discussed. For instance, Dr. Cumming's two papers (abstracted on page 8 of our January issue) did not receive the adequate discussion which they really merited. The paper first read dealt with "Studies in Strong Electrolytes." The discussion was opened by Mr. Wilmore, who pointed out Planck's hypothesis necessitated ions of some valency. Dr. Cumming's work had eliminated these, and thus permitted the measurement of two electrode voltages. Dr. Lowry, who presided, referred to the curves on page 4, and asked how the true value had been obtained. As regards John's work, Dr. Lowry pointed out that concentration was not a measure of conductivity for solution of 1/100-normal, which was from the point of view of the electrolytic dissociation comparatively concentrated. In reply Dr. Cumming mentioned that the true value curve had been obtained by calculation, and that his own conclusions were that conductivity varied with the concentration up to one-half normal.

Dr. Cumming then read his paper on the "Electrochemistry of Lead," which had been presented at the November meeting. The discussion was opened by Dr. Hutton, who said that the Society was to be congratulated upon receiving such papers as those by Dr. Cumming. Far too many pieces of good research work were buried in the German papers, and merited a wider publicity than they received. Mr. Wilmore thought that this paper would be of value in accumulator work, and permit the re-calculations of Dolezalek formulae in terms of the tetrad lead ions instead of the PbO_2 ions. Mr. H. L. Joly remarked that oxygen was tetravalent in certain organic compounds. Dr. Lowry, in proposing a vote of thanks to the author for his two papers, thought that the latter might help in the elucidation of many accumulator mysteries.

This reference paved the way to the third paper of the evening, by Mr. R. W. Vicarey, on "Storage Batteries and Their Electrolytes," (also abstracted on page 8 of our January issue,) which, in the author's absence was read in abstract by Mr. Spiers. Mr. Joly then made a scathing attack on the paper, declaring that any paper submitted for discussion to a scientific Society should be the crystallized embodiment of careful experiment and sound theory. Mr. Joly declared that the present paper contained neither, and took paragraph by paragraph. For instance, the author had talked of uniformity, yet if standard dimensions, weight, discharge rate and number of plates were taken into consideration, prices would be found to vary from 6½d. to 1s. 2d. per pound. As regards ammonia, he had never found such quantities as had been mentioned. The author had for a long time been declaiming that ammonia would have to be thoroughly investigated. Then, why for goodness sake, didn't he investigate it and give them some figures? Mr. Vicarey claimed to have discovered what he called a hemi-basic sulphate crystal. The speaker begged to have samples for microscopic investigation. In short, they had had two papers from Mr. Vicarey, and were "no forrarder." Dr. Cummings criticized the author's use of platinum electrodes. A minute trace of platinum was

enough to ruin any accumulator. As to the evil effect of ammonia his (Dr. Cumming's) own practice had been to wash defective plates in ammonium acetate solution. Mr. W. R. Cooper hazarded the suggestion that the paper was perhaps written or compiled in a hurry. In any case the comparative figures on the second page only gave the figures in 1902. This table would have been more explicable if it had been up to date. Other tables were quite inexplicable—the gas liberated got greater as the current got less. Mr. Cooper also wanted to know more about the new sulphate of lead. The proceedings terminated with a vote of thanks to the author on account of the discussion which his paper had engendered.

ELECTRIC POWER AND THE METALLURGICAL INDUSTRIES OF THE RAND.

To the amazement of electrical engineers in London, the preference shares to the value of £650,000, in the Victoria Falls power scheme, offered for subscription, are reported to have been fully subscribed. This ornate and grandiose scheme has been severely criticized by competent authorities, such as Sir Alexander Kennedy and Mr. Robert Hammond, who hold the view that power distribution from falls nearly 700 miles away, even if transmitted at 120,000 volts and 12½ cycles per second, cannot possibly compete with a large steam-driven station *in situ*. As a matter of fact, the promoters do not seem to display anything approaching firm faith in the long-distance transmission side of the venture. They have acquired the existing steam-driven generating plant at Vereeniging, and their prospectus contemplated a reserve steam-driven station at the Rand as well as a large hydraulic reserve station.

Electric power is invaluable in mining operations and a really cheap supply will be a boon in view of the present conditions in the Transvaal. If the long-distance transmission scheme ever becomes anything more than a project, the inevitable demand for copper to which it will give rise will be an important "bull" point for copper dealers.

ASSAY OF GOLD.

The monthly meeting of the Institution of Mining and Metallurgy, held on the 13th of December, had only two new papers submitted for consideration. The first paper, by Mr. Arthur C. Claudet, dealt with "The Assay of Gold Bars as Conducted in the Author's Assay Office," and described the carefully elaborated routine followed from the preparation of the assay piece by flattening on an anvil, through the process of weighing (which is done in two stages on rough and fine balances), their cupellation in Fletcher's gas muffle furnaces, down to the parting of the silver from the gold and the weighing of the cornets. The author also described his method of refining gold for proofs or checks, in which 12 ounces of proof cornets are dissolved in nitro-hydrochloric acid in two flasks, then thrown into two porcelain dishes and evaporated until chlorine commences to be given off. The liquor is then taken up with distilled water, thrown into a large glass jar (25 inches high and 13½ inches diameter), and diluted quarter full. It is allowed to settle for three weeks at least, then syphoned off through a filter into a similar sized jar; 2½ pounds of pure oxalic acid, dissolved in water and filtered, are added and well stirred; a cover is put on the top of the jar, and it is allowed to stand two or three weeks, after which the liquor is syphoned off. The gold is collected in a porcelain dish and thoroughly washed by decantation with boiling distilled water, then with hydrochloric acid, re-washed with water, then washed with several fresh quantities of ammonia and water. Finally the gold is collected and dried, then placed in a clay fluxing pot and melted with a little nitre. The button, after breaking the pot, is washed with water and hydrochloric acid, re-melted in a plumbago pot and cast into a small, very clean mould; the bar is re-washed and got as clean as possible. Then it is rolled in rolling mills specially cleaned for the purpose, into a strip, which is thoroughly cleansed before use. Pieces of the gold thus obtained are

assayed before use by Johnson & Sons, and Johnson, Matthey & Co., and are invariably reported as 0.99995 to 1.00000.

The second paper, by Mr. G. F. Heath, described "The Water Race for the Chuquitambo Gold Mines, Peru," and is an interesting account of practical civil engineering construction. It does not, however, call for further description in these notes.

MARKET PRICES DURING DECEMBER.

The last day of the year naturally affords, not only an opportunity for speaking of prices during the preceding month, but, also, of saying a few words upon the year's records generally. Regarding the month, however, first, one has again to record a state of affairs in regard to the metallurgical industries wholly favorable to the producers of the raw material, but of high prices to the consumer.

Copper, which touched £108 per ton before Christmas, eased slightly owing to Christmas and New Year holidays, and closed at £105.5. Tin has been subject to relatively slight fluctuations, closing rather easier at £193.12.6, the holidays again tending to depress prices. The activity in the heavy engineering trades maintained pig iron at prices of over 60s.

per cwt. for Cleveland warrants closing at 62s. on Dec. 31. Lead has remained firm, closing at £19.17.6 per ton. The chief prices to be noted in regard to chemicals are sulphate of ammonia £12.5 per ton, bleaching powder (35 per cent) £4.12.6 per ton, copper sulphate £32 per ton, cyanide (98 per cent minimum) 8½d. per pound, potassium carbonate (90-92 per cent) £18.15 per ton, caustic soda, white (77 per cent) £10.12.6 per ton, zinc sulphate £8.10 per ton. Shellac £9.11 per cwt.

Of advances during the year, Cleveland iron has risen 9s. per cwt., lead has risen £2.1.3 per ton, copper £25.10 per ton, and tin £32.7.6. Twelve months ago I remarked that the general outlook in the engineering and allied trades looked very favorable. Now we are in full swing, with many works booked up with orders for several months. Late deliveries of steel, both rolled and cast, are giving a good deal of trouble. Continued activity seems probable, the only disturbing element being the fear of bad harvests abroad, which would restrict the purchasing powers of certain large non-manufacturing countries.

LONDON, Jan. 5, 1907.

ANALYSIS OF CURRENT ELECTROCHEMICAL PATENTS.

ELECTRIC FURNACE.

Crucible for Induction Furnace.—E. A. Colby, 840,825 and 840,826, Jan. 8. Application filed Nov. 23, 1905.

These two patents refer to the mechanical construction of the annular crucible containing the molten charge in an electric induction furnace. The cross-section of the design of patent 840,825 is shown in Fig. 1. B is the chamber containing the molten charge, while A is a recess, which may be filled with heat-insulating material, like magnesia or asbestos, or

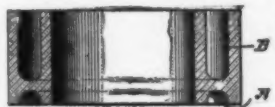


FIG. 1.—CRUCIBLE.

may be left empty to reduce loss of heat by condensation; or the primary inducing coil may be placed in it. Patent 840,826 refers to the construction of the annular crucible of a number of arc-shaped sections, fitted together by keyways and keys in dovetail shape.

Fused-Quartz Receptacle for Electric Furnace.—Wm. H. Bristol, 839,983, Jan. 1. Application filed Aug. 6, 1901.

Within heat-insulating walls of fire-clay or magnesia, etc., a crucible is placed of fused quartz, around which the heating wire of platinum is wound.

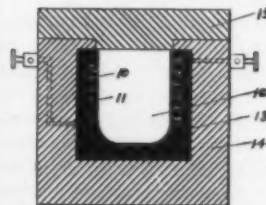


FIG. 2.—ELECTRIC FURNACES.

The advantage of using a fused quartz crucible is that fused quartz has practically a zero negligible coefficient of expansion with heat. (A fused quartz crucible may be heated red-hot and will not crack if water is poured in.) For this reason, if the furnace is to be used, the full current may be turned on immediately without any use of rheostats, etc., and without any danger of the quartz crucible cracking. A great saving of time thus results in the use of the furnace. A crucible furnace of this type is shown in Fig. 2, in which 14 are the refractory walls of fire-clay or magnesia, etc., 13 a layer of asbestos, 11 the heating platinum resistor and 10 the furnace quartz crucible. To generate sufficient heat in the platinum resistor the inventor makes it of flattened form, and winds it edgewise with respect to the receptacle, as indicated in the illustration.

Carbon for Electrical Resistances.—E. G. Rivers, 841,572, Jan. 15. Application filed Dec. 22, 1905.

The object is to prepare carbon "for use in the formation of electrical resistances and heater elements and as a paste for mounting and jointing electrical conductors for joining up platinum wires with carbon filaments in the manufacture of incandescent electric lamps and for analogous uses." Finely powdered retort carbon is made into a solid body of high resistance by first forming it into a paste with a solution of soluble silica or water-glass, and then subjecting the mixture to a high temperature, and also, in cases where extreme hardness is required, to the subsequent action of a solution of carbonic acid or other weak acid which will act upon and decompose the silicate.

Electric Melting or Reducing Furnace.—Gilbert C. Landis, 842,090, Jan. 22. Application filed Sept. 21, 1904. Assigned to American Phosphorous Co.

The metallic casing B (Fig. 3) contains a lining A of vitrified bricks united by a non-absorbent mortar (f. i., one com-

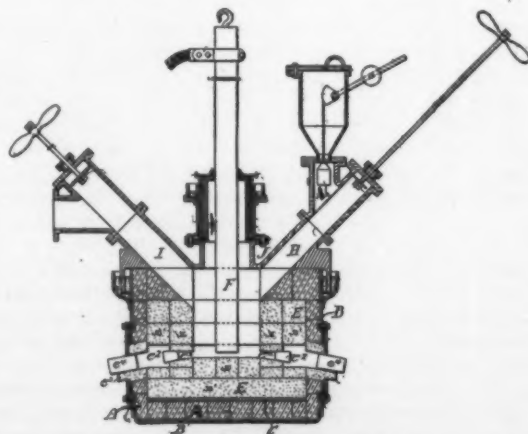


FIG. 3.—PHOSPHORUS FURNACE.

posed of silicate of soda and powdered asbestos). The blocks are vitrified to prevent the absorption and loss of fumes and gases from the furnace. Then follows a lining E, composed of blocks of carbon, and this lining E is composed of an

inner set of blocks x and an outer set of blocks x^1 , so that when in the operation of the furnace the inner blocks become worn away they can be replaced without disturbing the outer blocks x^1 . The carbon lining E rests upon a base plate C of conducting material, from which connection is made to the outside, forming one terminal. The other terminal is applied to the vertical adjustable carbon electrode F , which is fitted in the vertical neck J of the cap plate G . There are also two inclined necks on the two sides, one, H , for charging with the aid of a hopper, the other, I , being the exit of the fumes and gases. These fumes and gases are the desired product of the furnace reaction. The molten slag is tapped off through inner tapping holes e^1 (with plugs e^2) and outer tapping spouts e^3 (with plugs e^4). By providing inner and outer tapping openings the inventor is "enabled to use a plug e^2 of wood for the inner opening without luting, as it is difficult of access," while the outer opening is closed "by the plug e^4 , which is luted, preventing air reaching the inner wooden plug." The furnace is continuous in its operation. Since the tapping openings are, by reason of the friction of the flowing slag, worn away more rapidly than the blocks of the inner carbon lining x , two sets of tap openings are provided, in order to use the second one after the first is worn out.

Electric Furnace.—Leon Dion, 840,481, Jan. 8. Application filed April 30, 1906. Assigned to Americus Electro-Hermetic Co.

A stack furnace is provided with two sets of electrodes passing through opposite walls, so that the ends of the opposite electrodes are near together. In this way on either side of the furnace a number of electrodes (preferably in form of plates) are mounted one above the other. From a hopper at the top the raw material drops down through the space between the two opposite sets of electrodes and is fused, and the product is collected in a crucible at the bottom.

Electric Resistance Furnace.—Clarence L. Collens, 2d, 840,044, Jan. 1, 1907. Application filed Dec. 1, 1905.

The object of an improved design of a resistance furnace must be to increase "the surface of productive heat diffusion" without increasing "the surface of non-productive heat diffusion." (Concerning the definition of these terms see the inventor's paper, our Vol. IV., p. 212). Under this condition the time required to manufacture a given volume is reduced and the waste of energy is diminished. To accomplish this, the design shown in Fig. 4 is employed. The materials to be treated are ground and molded into blocks P of a predetermined size, using some such bond as pitch, tar or glue water.

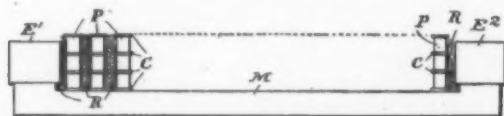


FIG. 4.—ELECTRIC RESISTANCE FURNACE.

These blocks are then placed in the furnace in tiers, the bed of the furnace between the terminals E^1 and E^2 having been first filled with some good refractory material M , which is a poor conductor of heat and electricity. Thin slabs C of graphite or carbon (or even metal, if the temperature of the reaction is low) are placed between the blocks P . The spaces between the tiers are filled with the resistance material R . The outer side walls of the furnace are then built up and the space between these and the tiers is then completely filled in with the refractory material M . The electric current passes from terminal E^1 to the first layer of resistance material R , then through slabs C to the next layer of resistance material R , and so on. The chief advantage of this design is stated as follows: "By making the blocks P of one-half the width and the zones of heating of one-half the thickness the surface of productive heat diffusion can be practically doubled without increasing the total volume of the resistors or the area of the

surface of non-productive heat diffusion. By still further subdivision within certain practical limits any degree of distribution of the heat generated throughout the mass under treatment can be obtained, each sub-division resulting in an increase of thermal efficiency without a corresponding proportionate increase in the labor costs or a decrease in the ease of construction and operation." Another advantage is that "if the slabs C possess higher electrical conductivity than the material under treatment the latter is practically short circuited by these slabs, and hence any change in the conductivity of the blocks P during the run does not materially alter the resistance of the furnace as a whole. The voltage regulation therefore does not require a wide range, and the source of electrical supply is a simpler less expensive style of apparatus than with some other types of incandescent furnaces."

ELECTROLYTIC PROCESSES.

Electrolyte for Production of Alkali Metals.—G. O. Seward and F. von Kùgelgen, 841,724, Jan. 22. Application filed April 23, 1906.

In the electrolytic production of the alkali metals from their chlorides it is necessary to employ an electrolyte of low melting point, for the reason that the output of metal decreases as the temperature of the bath increases. The new electrolyte of the inventors consists of the chloride of the alkali metal sought, a fluoride of the same metal, and a chloride of an earth-alkali metal, for instance, a mixture of four parts NaCl , two parts NaF and one part BaCl_2 . This mixture remains fluid below a red heat. For the production of potassium a mixture of KCl , KF and BaCl_2 is used. Besides their low melting point these electrolytes have the advantage that there is no danger of contaminating the alkali metal sought by another alkali metal, "since the earth-alkali salt is not decomposed at the current density used in the production of the alkali metal."

Lead and Zinc from Sulphide Ores.—C. E. Baker and A. W. Burwell, 841,102, Jan. 15. Application filed July 5, 1904.

Dry ore, containing the sulphides of lead or zinc, is finely pulverized and brought into contact with vapor of sulphur chloride S_2Cl_2 in a revolving drum. Heat is applied to hasten the reaction, which is represented by the equation $\text{MS} + \text{S}_2\text{Cl}_2 = \text{MCl}_2 + 3\text{S}$, where M is a metal, like lead or zinc, whose chloride is fusible. The sulphur is recovered and the fused lead or zinc chloride is electrolyzed with graphite anodes and molten lead or zinc cathodes. The chlorine set free at the anode may be used for producing sulphur chloride, which is employed again in the continuation of the process.

Copper from Sulphide Ores.—C. E. Baker and A. W. Burwell, 841,103, Jan. 15. Application filed March 1, 1905.

Copper sulphide is first treated like lead and zinc sulphides in the preceding patent. The reaction with sulphur chloride yields sulphur and cuprous chloride which is leached out and electrolyzed.

Copper, Nickel, Cobalt from Ores.—John H. Ryan, 841,720 and 841,721, Jan. 22. Application filed March 1, 1906.

The object is the treatment of ores containing copper or nickel or cobalt or all of these metals in combination with sulphur or arsenic. The finely-ground ore is first subjected to a roasting operation in a number of successive stages at gradually increasing temperatures. The inventor prefers a McDougall furnace with a pyrometer in each shelf, a constant temperature being maintained on each shelf, but the temperature increasing from shelf to shelf downwards. On each shelf the ore is rabbled under constant temperature conditions, maintained by manipulation of hot and cold air inlets for a definite time before being transferred to the next shelf below, where the treatment is continued at a suitable higher temperature. The following figures are given as to the successive stages: Roasting for 1 hour at 300°F ., then for 1 hour at 450°F ., then for 1 hour at 800°F ., finally for 1 hour at $1,000^\circ\text{F}$. The ore is then discharged while still hot into a suitably dilute solution

of sulphuric or sulphurous acid for the preparation of a sulphate or sulphite solution. (The acid solution is preferably prepared from the gases derived from the roasting in well-known manner.) In the case of ores containing nickel or cobalt it is advantageous to add to the ores before conveying them to the roasting furnace about 2 or 3 per cent of sodium chloride. The initial temperature of the leaching solutions should be not less than 150° F., and where electrolytic deposition of the metals is employed the deposition should be effected at a temperature not below 80° F. After the metals (copper, nickel, cobalt) yielding soluble sulphates or sulphites are extracted the tailings are treated for the recovery of precious metals. For this purpose they are neutralized by lime or by the hydroxide or carbonate of sodium or potassium, and are then subjected to the solvent action of a cyanide solution and the gold and silver are recovered in the usual manner. When treating cobalt ores containing gold and silver, it is advantageous to regrind the tailings wet. The leaching operation must be varied somewhat in accordance with the character of the ore. For copper ores the copper is electro-deposited in a continuous depositing tank. In case iron is present in the ores it passes into the solution, the iron salts being oxidized in the region of the insoluble anodes. Such salts when returned to the leaching vat become effective solvents for the compounds of copper. When both copper and nickel are present the copper is precipitated as sulphide and the nickel separated by electrolysis with insoluble anodes, the copper sulphide being either redissolved and the metal electro-deposited or else reduced to metal, cast into anodes and electrolytically refined.

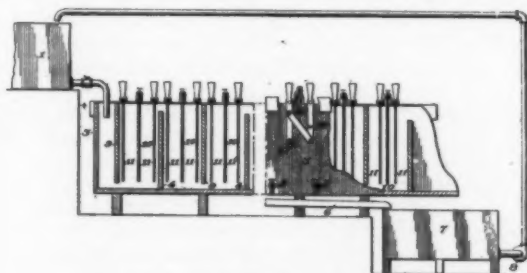


FIG. 5.—ELECTROLYTIC TANK.

In case nickel and cobalt are present together in solution, an alkali hydroxide is added in quantity just sufficient for the precipitation of the nickel, thereafter the cobalt is electro-deposited from the clear solution. The nickel may be recovered in any suitable manner, as by solution of the hydroxide and electro-deposition of the metal or by conversion of the same into metal anodes suitable for electrolytic refining.

The tank for the electrolytic metal deposition (patent 841,720) is shown in Fig. 5, where 1 is the leaching tank and 3 the electro-depositing tank. The latter is divided by the partitions 4 and 9 into a series of compartments so as to force the electrolyte to pass through the tank in a zigzag course. By means of the draw-off cocks 5 the contents of the different compartments may be discharged into a launder 6, leading to the sump 7, from where the solution is pumped back into the leaching tank. The cathodes 10 are thin sheets of the metal to be deposited. The insoluble anodes 11 may be of lead. Since the electrolyte becomes gradually impoverished during its passage through the tank, the anodes and cathodes are placed nearer together at the outlet end of the tank than at the inlet end.

Treatment of Sulphide Ores.—R. S. Packard, 840,511, Jan. 8. Application filed Jan. 11, 1906.

The object is to convert copper or zinc sulphides into sulphates by means of chlorine set free from an acid solution containing the pulverized unroasted ore. A strong solution of hydrochloric acid or a strong brine solution, kept acid by hydrochloric or sulphuric acid, is used as electrolyte. The

theory of the inventor is that chlorine set free at the anode reacts with the water, forming hydrochloric acid and oxygen, which "oxygen being liberated in the nascent state in immediate contact with the sulphide particles oxidizes energetically" the sulphides to sulphates. Fig. 6 shows the construction of the tank. It has a removable false bottom, so arranged that the anodes and cathodes pass through it and reach to the bottom of the tank. The anodes are carbon rods, the cathodes

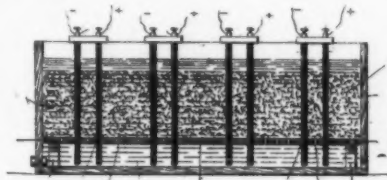


FIG. 6.—TREATMENT OF SULPHIDES.

either carbon rods or copper or iron sheets enveloped in linen clothes to retain the copper which is precipitated loosely upon them. After the copper has been leached out of the ore, the solution is tapped off into a precipitating tank containing scrap iron, upon which the copper is precipitated in form of sponge or cement copper. "If the copper ore contains gold, the action of the current should be stopped long enough before tapping to insure the complete chloridizing and solution of the gold, some of which may have been precipitated at the cathode by the reducing action of the ferrous salt formed there. The chlorine will convert the ferrous into a ferric salt and dissolve the gold. The gold may be precipitated by the addition of ferrous sulphate to the solution in a separate tank previous to the precipitation of the copper."

Water Purifying Apparatus.—A. E. Dieterich, 838,390, Dec. 11, 1906. Application filed Oct. 11, 1906.

A cylinder contains a core of non-conducting waterproof material, upon the outside of which a spiral groove is formed extending from end to end. The water enters the cylinder at one end and passes through the groove, where it is subjected to electrolytic action by means of two aluminium strips, so as to "precipitate the impurities in the water." When the water reaches the other end of the groove it enters the lower end of the interior of the hollow core, which is filled with filtering stone where the impurities are deposited. The purified water then leaves at the other end.

Water Purification.—Jacob A. Hyle, 840,335, Jan. 1. Application filed April 3, 1906.

The inventor claims (claim 5): "In an electric water-purifying and filtering system, a reservoir having a concaved bottom, a cleaning pipe attached to the bottom of the reservoir and provided with a valve, outlet pipes leading from the reservoir, filter connected to said pipes, a service pipe leading from the bottom of the filters, and an inlet pipe having a contracted discharge end and containing an electrolytic cell composed of longitudinally-extending pipes, end discs and a corrugated cell plate surrounding the pipes, and electric connections for the plate and discs respectively."

STORAGE BATTERIES.

Battery Plate.—F. C. Hood, 837,567, Dec. 4, 1906. Application filed Feb. 20, 1906.

The plate is composed of a continuous series of superimposed loops of finely corrugated lead tape. The loops are formed by laying the tape back and forth on a horizontal surface, leaving a relatively wide space between the sides of each loop. Separate strips of more deeply corrugated lead tape are interposed between the arms of each loop. This network is held together by vertical and horizontal lead bars.

Connector for Batteries.—A. F. Clark, 837,897, Dec. 4, 1906. Application filed May 12, 1903.

Details of mechanical construction of connections for bridging the terminals of successive battery cells.

Coating Active Material with Flake-Like Conducting Material.—T. A. Edison, 839,371, Dec. 25, 1906. Application filed March 30, 1905.

The object is to coat electrolytically-active nickel hydroxide or other active salt with flake-like conducting material, such as flake graphite or flake nickel or cobalt, etc. (for the purpose of increasing the conductivity of the active masses in the Edison battery). Nickel hydroxide is ground and mixed with molasses. Flake graphite is added and the mixing is continued. Two parts by weight of flake-graphite are applied to eight parts of nickel hydroxide. The mass is dried and filled under slight pressure into the pockets of the battery grid, which are then immersed in slightly alkaline water to dissolve the molasses. The pressure is then increased to its normal value.

Plante Plate.—Jang Landsing, 839,606, Dec. 25, 1906. Application filed Nov. 24, 1905. Assigned to General Storage Battery Co.

The object is to prevent buckling of a Plante plate, due to the thickening and elongating of the lead strips during the process of formation. The plate is made up of a frame provided with ribs. Within this frame and ribs, panels or elementary grills of lead are provided. Each panel consists of several series of vertical lead strips (which are to become active). At top and bottom these strips are provided with flexible cross supports. Recesses are cut into the outer surfaces of these cross supports in order to permit longitudinal elongation of the grill, while holes are formed in the two ribs at the side of the grill to permit sidewise elongation.

Plante Plate.—Joseph Bijur, 839,711, Dec. 25, 1906. Application filed Aug. 15, 1906. Assigned to General Storage Battery Co.

The object is to avoid straining or deformation of Plante plates. How this is accomplished is well indicated by the sixth claim, which is for a "Plante battery plate comprising frames having sides and ends and transverse and longitudinal cross-ribs provided with apertures at their intersections, active unit elements in the form of grills comprising strips connected to diagonal or cross supports, projections or trunnions at the centers of said grills, said trunnions being adapted to co-operate with the apertures at the intersections of the cross-ribs on the frames for supporting the grills centrally between the frames, said grills being supported without touching each other and without touching the frames except at their central portions, and means for centering said grills upon the frames." In one construction of grill shown and stated to be satisfactory, four sets of parallel strips are connected to diagonal supports, thereby dividing the plate into segments or quarters of pyramidal form.

Battery Connection.—Joseph Bijur, 839,712, Dec. 25, 1906. Application filed Oct. 17, 1906.

Mechanical details of construction of the connection between the plates and the strap connecting the plates together.

PRIMARY BATTERIES.

Dry Cell.—John W. Brown, 838,165, Dec. 11, 1906. Application filed June 4, 1906. Assigned to National Carbon Co.

The object is to prevent the deterioration of dry cells. For this purpose the entire filling of the zinc cup of the dry cell is wrapped up in paraffin paper, which not only prevents vaporization of moisture, but insulates the zinc cup electrically from the filling. In this condition the cell is absolutely inert. When it is to be used, the inner package is taken out of the zinc cup, the paraffin paper is removed and the package is placed back into the cup.

Primary Cell.—Benj. J. Blameuser, 838,372, Dec. 11, 1906. Application filed June 7, 1905.

The object is to maintain constant concentration and composition of the electrolytes in a double-fluid cell, like the bichromate battery. During operation the sulphuric acid becomes zinc sulphate and gets thereby heavier, while the bichromate solution is reduced and becomes lighter. This change of specific gravity is made use of for automatic circulation of the liquids between the two compartments of the cell and two reservoirs containing fresh electrolytes.

Porous Diaphragm.—Frank A. Decker, 839,816, Jan. 1, 1907. Application filed March 9, 1905.

"In the electrochemical diffusion of fluids through porous diaphragms the rate of diffusion at different elevations varies with the depth or fluid pressure and results in a gradually increasing exhaustion of the fluid from the surface downward." To counteract this effect, the inventor constructs a porous cup in the form of a truncated wedge, composed of two diaphragms, with wide base flanges, sealed together to form a wide bottom, and gradually decreasing end flanges which are sealed together to form the ends of a container having a comparatively small cross-sectional area at the top, gradually increasing toward the bottom.

Coupling for Battery Elements.—Frank A. Decker, 839,817, Jan. 1, 1907. Application filed Jan. 22, 1906.

The third claim is for "a battery-electrode holder having a tapered socket and a slit therein, an envelope and a conductor to which said holder is engaged, and an electrode having an ear thereon which fits said socket, and has its connection with said electrode disposed in said slot." (Concerning the Decker cell see our Vol. IV., p. 441.)

SYNOPSIS OF PERIODICAL LITERATURE.

A Summary of Articles Appearing in American and Foreign Periodicals.

ELECTROCHEMICAL ENGINEERING.

Electric Steel.—In our last issue, page 25, we gave a brief abstract of the recent paper of Prof. Eichhoff on the working of the Héroult process in the plant of Richard Lindenberg, in Remscheid. Since in our columns the first authoritative information was given out concerning the Héroult process, and since we have paid continually close attention to all its developments, a great deal of the contents of Prof. Eichhoff's paper is no news to our readers. Nevertheless, some points of the chemistry of the process are brought out in an interesting way, and it is also interesting to note that the *Iron Age* of Jan. 31 gives considerable space to the subject. Concerning the possibility of the electric furnace competing with the open-hearth and Bessemer processes, the author points out

that at present success seems promising only where cheap power is available. In 5-ton furnaces the power consumed is between 870 and 750-kw-hours if cold scrap is the starting material. If, however, molten metal is taken from an open-hearth furnace or a Bessemer converter and over-blown, and thus delivered into the electric furnace, the power consumption is from 200 to 300-kw-hours in 5-ton furnaces, according to the purity of the product required. With larger furnaces the consumption of power per ton of output is very much diminished. This is indicated by the fact that in a 1.5-ton furnace 48 per cent of the electrically-generated heat is lost by radiation; of course, with increased dimensions the radiation loss per ton of output can be very much diminished. Whenever large sizes of furnaces are used with cheap power, the pros-

pects of competition with open-hearth and Bessemer steel are not so bad, especially if it is considered that the Héroult furnace enables other savings. For instance, it requires little or no ferromanganese, the manganese being reduced directly from additions of ore. Only the theoretical amount of ferrosilicon need be charged and cheaper starting materials lower in grade may be used. However, up to the present the Héroult process has been applied only for the production of high-grade special steels in competition with the crucible process, and in this respect the results obtained at Remscheid are extremely satisfactory.

Prof. Eichhoff called attention to two special points which are important, namely, that of deoxidation and that of chemical purity. With respect to the former point he expresses the opinion that the boiling of steel and the occurrence of pipes and blow-holes are mainly due to iron oxides dissolved in the steel. This solution of iron oxides must be prevented, and for this purpose heretofore ferromanganese and ferrosilicon have been added. This has the disadvantage that manganese and silicon when combining with the oxygen form solid oxides, which remain in the steel in a finely divided state. Further, every basic slag contains iron oxides in solution, which will react with the molten bath and a thorough deoxidation is impossible. The special point of the Héroult process is that the slag is perfectly free from iron. With the electric process those elements which can be oxidized, like phosphorus, sulphur, manganese and silicon can be completely controlled; phosphorus, to the extent of 0.003 per cent and sulphur below 0.01. Copper, arsenic, etc., cannot be removed, but these elements are not deleterious themselves but only through their sulphur compounds.

The Héroult process, as carried out at Remscheid, is described as follows: "From a Wellman tilting open-hearth furnace 1.5 to 2 tons of liquid steel, partially purified, is cast into the electric furnace, care being taken to hold back the slag. The bath is covered with an oxidizing slag, and the current is turned on. After the lapse of one-half to three-quarters of an hour the slag is carefully drawn off, the clear bath is covered with a certain amount of carbon and a fresh amount of slag, free from oxides, is charged. This slag is melted after 20 minutes, and then through the action of the arc upon the slag, it is thoroughly deoxidized, calcium carbide being formed. In this manner the bath is completely protected against access of air. The charging of the neutral slag cools the bath so much that the greater part of the protoxide of iron is reduced by the layer of carbon. A certain quantity of manganese ore is also charged with the neutral slag. This, too, is reduced and destroys the last small balance of the protoxide of iron. When the slag has become quite white a sample of the steel is taken and its carbon content is determined. Then a mixture of iron and carbon, accurately calculated, is added, and, when dissolved, the necessary addition of manganese and of ferrosilicon is charged to produce the desired quality. The steel is then tapped. So far as phosphorus is concerned the analysis of the steel in a well managed charge fluctuates between 0.003 and 0.005 per cent, while sulphur ranges from 0.007 to 0.012 per cent. As a rule, carbon, manganese and silicon can be accurately kept within limits of 0.03 to 0.05 per cent."

The elimination of the sulphur takes place during the last stage of the process, and seems to be due to the fact that a much more basic slag can be used in the electric process on account of the much higher temperature available. When the steel is taken in a highly oxidized condition from the Wellman furnace it carries only about 0.01 per cent of phosphorus, and may be directly covered with carbon and the neutral slag. This makes it possible to finish a charge in 1¼ hours with a consumption of power of 200 kw-hours per ton of steel.

There is no danger of the very high temperature spoiling the charge, since there is always thorough circulation in the bath, and all particles, in the bath come into contact with the slag,

the highest temperature being concentrated in the slag layer.

Prof. Eichhoff quotes some results reached by Guillet, the distinguished Paris metallurgist, on the properties of steel made by the Héroult process in comparison with the best crucible steel. With equal toughness it permits of a carbon content from 20 to 40 per cent higher, and therefore has a greater resistance to wear. It has a strikingly high elastic limit and contraction of area. It is completely free from blow-holes, and, therefore, when the process has been properly conducted, no surface defects or longitudinal cracks appear. It is completely deoxidized and contains no "emulsion" of silica or manganous oxide. The presence of copper and arsenic has no injurious effect, so long as practically no sulphur is present. Segregations of phosphorus and sulphur do not occur. It forges better and stands a higher heat better than crucible steel. The cost of production is far below that of crucible steel. It is independent of the quality of the raw material. Its manufacture is coupled with less exertion for the workmen than that of crucible steel. In purity it excels nearly all crucible steels. The process makes it possible to produce any kind of alloy steels, even such whose analysis has been thought to be impossible hitherto.

Steel produced may be kept for hours under a neutral slag without changing its quality, and a part of the heat may be cast and the balance be worked over to another grade—a matter which is of great importance to steel foundries. The steel may be allowed to chill and be melted over again without hurting its quality.

Fixation of Atmospheric Nitrogen.—The *Elektrotechnische Zeitschrift*, of Jan. 10, contains the first part of a paper by G. Erlwein, of the Siemens-Halske Co., on matters connected with the development of the cyanamide process. In the introduction he mentions some work done in the laboratory of his company tending towards the development of a method of producing nitrogen oxides from air by electric discharges. In the first method described an arc is formed between impregnated thick carbon electrodes (such as used in the Bremer arc lamp and in flame arc lamps), and the arc is blown and spread out by means of magnetic deflection. In the second method the arc is made to move and extinguish in the same way as in the well-known horn lightning arresters. In fundamental principle both methods are quite similar to the well-known Birkeland-Eyde process. The main part of the paper, however, refers to the production of cyanamide in the electric furnace, and we reserve a more complete review of the paper for a coming issue, when the complete paper of Erlwein will be available.

COPPER.

The Pyrite Process of Smelting at Mount Lyell, Tasmania.—Pyrite smelting at Mount Lyell has been brought to a high standard of metallurgical efficiency by Mr. Robert Sticht, the well-known manager of the smelting works. A general review of the practice at the smelter is given by Mr. R. Nicholls, late assistant manager of the works, in the *Journal of the Chemical, Metallurgical and Mining Society of South Africa*, November, 1906. After reviewing in general the process of pyrite smelting the author begins the description of Mount Lyell practice by giving the analysis of the ore at Mount Lyell, the sample being taken from the open-cut workings of the mine. The analysis shows the following percentage constituents: SiO_2 , 2.96 per cent; Fe, 41.2; BaSO_4 , 2.16; Al_2O_3 , 1.63; Cu, 2.4; S, 48.28. The reduction of the ore at Mount Lyell is effected in three stages, the first and second in the blast furnace, the third comprising the reduction of the enriched matte by Bessemerizing. The usual practice was formerly the smelting of the ore in blast furnaces, with the addition of silicious and calcareous fluxes, as well as 2 to 3 per cent of fuel in the shape of coke, using a heated air blast. By this operation a matte containing from 12 to 20 per cent copper was produced, the grade varying, of course, with the values in the ores smelted, with an average concentration of

4 to 5 into 1. The recent procedure has been modified by the use of ores which consist of silicious schists that carry copper in the form of erubescite, chalcopryite and copper glance. The analysis of these schists is about as follows: SiO_2 , 64 to 61 per cent; Fe, 7 to 3 per cent; Al_2O_3 , 14 to 20 per cent; Cu, 1 to 5 per cent. A typical slag run in the blast furnaces is as follows: SiO_2 , 38.5 per cent; FeO, 46.26 per cent; CaO, 5.90 per cent; BaO, .32 per cent; Al_2O_3 , 7.47 per cent; Cu, .65 per cent. The second operation consists in concentrating the first matte to a second matte of 45 to 60 per cent copper, the rate of concentration being about 3 into 1. The concentration of the matte in the second operation is carried out on similar lines to the first operation, as it is smelted with silica or silicious flux, limestone and return slag from Bessemerizing. The matte is then Bessemerized, the final product being a blister copper containing about 98 per cent copper, 60 to 200 ounces of silver per ton and 3 to 7 ounces of gold per ton. Some data concerning the process of pyritic smelting at the Mount Lyell works are also given in an article by Mr. Robert Sticht, the above-mentioned manager of the works, in *Metal-lurgie*, Nov. 22, Dec. 8, 1906. In a recapitulation of his remarks he states that it has not been possible to permanently carry out the ideal pyrite-smelting process, that is to say, the process in its most perfect form, where neither coke nor hot air is required. Even when it was possible to get along for a time without the use of coke, heated blast had to be employed, and at the present time, when the wind is blown in cold, it is necessary to use some coke. If this small addition of coke is omitted, the disturbances which appear after some time, owing to the furnace getting cold and hanging, occasion more loss than the saving in coke is worth. Inasmuch as the Mount Lyell smelter has now reached the limit of its present facilities for blast, nothing can be done in the direction of a greater volume of blast. It is the intention, however, to enlarge the blowing plant in the near future. The furnaces are blown at the present nominally with 17,000, and often 20,000 cubic feet, of air of 48 to 52-ounce pressure per minute, and 95 per cent of the Fe in the charge is oxidized. In reality, the amount of air entering into the furnace is less, because the losses in the blowers are larger than they can be experimentally determined in measurements, and because a considerable part of the air is lost in the flues and at the furnace. The amount of blast at disposal ought to be increased under the circumstances, and this increase should not only serve the purpose to oxidize still more Fe and S, that is to say, to oxidize a compound of sulphur nearer to the mono-sulphide, but in general to carry out more extensively the dynamic processes in the furnace beyond stages reached at the present time. By this means it should be possible to substitute the small number of Calories furnished by the coke, namely, per unit of weight of charge, nominally about 68, but effectively by reaction with SO_2 only about 22, by a greater generation of heat from the ores themselves. An addition of coke hinders, under all circumstances, the oxidation, and it is therefore a disadvantage where the calorific effect of Fe and S as in the present case, should be used as the only source of heat on account of the high percentage of these two bodies. The experiments of Hollway and the process of Bessemerizing copper both show clearly that the use of coke is not absolutely necessary, and the best proof is furnished by the latter process, for the reason that the sulphur compound which initially burns in the converter is identically the same in the pyrite furnace. It is therefore only requisite to run closer to the pneumatic conditions of the Bessemer operation in a pyrite furnace than has been done up to the present time. It is, of course, self-evident that the admission of air cannot be increased up to the point where the flame, so to speak, is blown out again. Mr. Sticht states that it is the intention at Mount Lyell to increase the height of the furnace considerably in the near future, and this should contribute towards reaching the goal of melting pyrote without coke and with cold blast.

ZINC.

Alloys with Iron.—S. Wologdine, in Prof. Le Chatelier's laboratory, has studied these alloys up to 10 per cent of iron; the results are given in *Revue de Metallurgie* for December. The alloys were made by putting small pieces of galvanized iron wire into melted zinc and heating to 700° to 800° in a clay crucible. For using the microscope, polished sections were attacked by a solution of 5 parts iodine in 100 of absolute alcohol, and a solution of lead chloride. Even with 0.07 per cent of iron clear-cut crystals begin to appear, which, by reason of their hardness, stand out on the polished sections. The quantity of these crystals, with clear-cut outlines, increases with the proportion of iron until with 8 per cent they cover the entire surface. On dissolving away the pure zinc entirely by lead chloride solution, the residue showed 8.14 per cent of iron, corresponding pretty well to the formula FeZn_{10} . The fusibility curve showed the melting point rising at the rate of 55° per 1 per cent of iron, attaining a maximum of 755° for the proportions FeZn^{10} , with 8 per cent iron, then falling off to a probable eutectic of FeZn^{10} with Fe, containing 10.15 per cent of iron and melting at 690°. Alloys with less than 6 per cent of iron showed an arrest while cooling at the melting point of zinc, while the alloy with over 8 per cent of iron showed an arrest at the melting point of the eutectic just mentioned.

IRON AND STEEL.

Constitution of Iron-Carbon Alloys.—In *Revue de Metallurgie* for December, Prof. Le Chatelier reviews and criticizes the conclusions of Mr. A. Sauveur's article on this subject, read before the Iron and Steel Institute, and abstracted in this journal for September, 1906, page 356. Le Chatelier points out that the distinction drawn by Mr. Sauveur between the solid state and the liquid state, is contrary to the basic principles of the phase rule, which ignores completely any distinctions between the solid, liquid or gaseous states of one and the same substance. The differences between these three states is solely that of a larger or smaller coefficient of viscosity, simply a question of *more or less*, and the drawing of sharp lines of distinction between them is based on no scientific foundation, and is totally immaterial to the application of the phase rule. There are in reality only two distinct states of matter: the amorphous and the crystalline; and even of these the phase rule takes no account, being concerned only and solely with the question of the *non-miscibility* of different phases, and no person has the right to restrict the well-defined field of application of this rule. The only reservation to be made, in applying the phase rule, is that it concerns systems in equilibrium—a limiting state towards which natural phenomena approach indefinitely under any given conditions. Carbon differs in iron, however, as rapidly as salts in water, and iron is the one solid body in which the phenomena of equilibrium approach their most perfect realization. The application of the phase rule by Roozeboom, in his well-known diagram, is therefore perfectly legitimate and correct, and is unaffected by the erroneous criticisms of Mr. Sauveur. Roozeboom affirms simply that the separation of graphite and of cementite from an austenitic solution follow two distinct solubility curves; he nowhere states that free graphite, in the cooling iron, unites with iron to produce cementite, as is charged by Mr. Sauveur. It is simply a case of misunderstanding on the part of the latter. The experiments of Mr. Sauveur, in which he obtained in the same cooled specimen, both cementite and graphite, are easily explained; one rate of cooling causes cementite to separate, another very slow rate graphite, an intermediate rate both. The preparation of cementite is a state of labile equilibrium, which becomes a state of fixed equilibrium—graphite and ferrite—on slow enough cooling.

Rapid-Cutting Steels.—*Revue de Metallurgie* for December contains a leading editorial from the facile pen of Prof.

Le Chatelier, wherein the work of Mr. Taylor on "The Art of Cutting Metals" is reviewed so appreciatively that some of the pleasant things so gracefully said cannot but sound agreeably to the countrymen of Mr. Taylor. Two paragraphs are as follows:

"It is difficult to comprehend the amount of moral energy required for the following of one line of work twenty-five years—as one may say during the term of an average active human life. There is the secret of American preponderance. Immigration has drained towards the new continent most of the enterprising and active elements of the old world; the sons and grandsons of the first immigrants have preserved a part of these qualities. If, on the one hand, this energy in the service of bad passions has created some grand fillibusters of universal reputation, yet it must not be forgotten that in America the same energy is also in evidence in the same degree in men of honor and of industry: Roosevelt, Carnegie, Monsignor Ireland and many others less well known to us.

"Mr. Taylor belongs to this *pleiade* of men of action, who, by the sole force of their wills, have transformed the society in which they live. Since 1900 the industry of machine work has been completely revolutionized in the entire world; this result has been attained by the persevering efforts of one man. It is only justice to proclaim this fact and to express our admiration for such qualities which it would be doubtless difficult for us to imitate on our old and slightly-tired continent. We have, however, like the Romans in the period of the Decadence, still enough appreciation of the best in life to be capable of admiring such characters, as we would admire the finest work of art, and to know how to render homage to them as they pass."

Silicon and Carbon.—F. Wüst and O. Petersen, working in the metallurgical laboratory of the Technische Hochschule, in Aachen, have investigated the influence of silicon upon carbon in iron alloys; their paper is in *Metallurgie* for Dec. 22. The primary object of the investigation was to determine the maximum amount of carbon which could co-exist with definite percentages of silicon, as well as to determine the melting or freeing points and the critical points of such alloys. It was found that increase of silicon was accompanied by a steady decrease of carbon and a nearly steady increase of melting point. Iron and carbon alone possess a eutectic of 4.3 per cent carbon, but the introduction of silicon lowers the per cent of carbon in the eutectic; for any definite amount of silicon present there is a definite percentage of carbon which forms the eutectic. The experimental results are as follows:

Per Cent Silicon.	Per Cent Carbon.	Freezing Point.	(4)	(5)
0.19	4.21	1135° C.	1137°	— 2°
0.51	4.02	1135	1150	15
1.18	3.89	1145	1158	13
1.44	3.79	1185	1165	—20
2.11	3.70	1185	1170	—15
2.63	3.48	1185	1184	— 1
3.28	3.34	1175	1194	19
3.73	3.25	1205	1197	— 8
3.93	3.17	1195	1205	10
4.82	2.95	1195	1220	25
5.18	2.78	1205	1232	27
13.71	1.84	1215	1326	111
18.97	1.12	1235	1422	187
27.18	0.79	1235	1459	224

The authors speak of the increase of melting point caused by the silicon, but the increase shown is less than would be accounted for by the diminishing of the carbon. The melting point of pure iron being about 1,600°, and carbon diminishing its melting point about 100° per each 1 per cent present, the silicon really reduces the melting point of the carbon-iron

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4 to 5 into 1. The recent procedure has been modified by the use of ores which consist of silicious schists that carry copper in the form of erubescite, chalcopryrite and copper glance. The analysis of these schists is about as follows: SiO_2 , 64 to 61 per cent; Fe, 7 to 3 per cent; Al_2O_3 , 14 to 20 per cent; Cu, 1 to 5 per cent. A typical slag run in the blast furnaces is as follows: SiO_2 , 38.5 per cent; FeO, 46.26 per cent; CaO, 5.90 per cent; BaO, .32 per cent; Al_2O_3 , 7.47 per cent; Cu, .65 per cent. The second operation consists in concentrating the first matte to a second matte of 45 to 60 per cent copper, the rate of concentration being about 3 into 1. The concentration of the matte in the second operation is carried out on similar lines to the first operation, as it is smelted with silica or silicious flux, limestone and return slag from Bessemerizing. The matte is then Bessemerized, the final product being a blister copper containing about 98 per cent copper, 60 to 200 ounces of silver per ton and 3 to 7 ounces of gold per ton. Some data concerning the process of pyritic smelting at the Mount Lyell works are also given in an article by Mr. Robert Sticht, the above-mentioned manager of the works, in *Metallurgie*, Nov. 22, Dec. 8, 1906. In a recapitulation of his remarks he states that it has not been possible to permanently carry out the ideal pyrite-smelting process, that is to say, the process in its most perfect form, where neither coke nor hot air is required. Even when it was possible to get along for a time without the use of coke, heated blast had to be employed, and at the present time, when the wind is blown in cold, it is necessary to use some coke. If this small addition of coke is omitted, the disturbances which appear after some time, owing to the furnace getting cold and hanging, occasion more loss than the saving in coke is worth. Inasmuch as the Mount Lyell smelter has now reached the limit of its present facilities for blast, nothing can be done in the direction of a greater volume of blast. It is the intention, however, to enlarge the blowing plant in the near future. The furnaces are blown at the present nominally with 17,000, and often 20,000 cubic feet, of air of 48 to 52-ounce pressure per minute, and 95 per cent of the Fe in the charge is oxidized. In reality, the amount of air entering into the furnace is less, because the losses in the blowers are larger than they can be experimentally determined in measurements, and because a considerable part of the air is lost in the flues and at the furnace. The amount of blast at disposal ought to be increased under the circumstances, and this increase should not only serve the purpose to oxidize still more Fe and S, that is to say, to oxidize a compound of sulphur nearer to the mono-sulphide, but in general to carry out more extensively the dynamic processes in the furnace beyond stages reached at the present time. By this means it should be possible to substitute the small number of Calories furnished by the coke, namely, per unit of weight of charge, nominally about 68, but effectively by reaction with SO_2 only about 22, by a greater generation of heat from the ores themselves. An addition of coke hinders, under all circumstances, the oxidation, and it is therefore a disadvantage where the caloric effect of Fe and S as in the present case, should be used as the only source of heat on account of the high percentage of these two bodies. The experiments of Hollway and the process of Bessemerizing copper both show clearly that the use of coke is not absolutely necessary, and the best proof is furnished by the latter process, for the reason that the sulphur compound which initially burns in the converter is identically the same in the pyrite furnace. It is therefore only requisite to run closer to the pneumatic conditions of the Bessemer operation in a pyrite furnace than has been done up to the present time. It is, of course, self-evident that the admission of air cannot be increased up to the point where the flame, so to speak, is blown out again. Mr. Sticht states that it is the intention at Mount Lyell to increase the height of the furnace considerably in the near future, and this should contribute towards reaching the goal of melting pyrite without coke and with cold blast.

ZINC.

Alloys with Iron.—S. Wologdine, in Prof. Le Chatelier's laboratory, has studied these alloys up to 10 per cent of iron; the results are given in *Revue de Metallurgie* for December. The alloys were made by putting small pieces of galvanized iron wire into melted zinc and heating to 700° to 800° in a clay crucible. For using the microscope, polished sections were attacked by a solution of 5 parts iodine in 100 of absolute alcohol, and a solution of lead chloride. Even with 0.07 per cent of iron clear-cut crystals begin to appear, which, by reason of their hardness, stand out on the polished sections. The quantity of these crystals, with clear-cut outlines, increases with the proportion of iron until with 8 per cent they cover the entire surface. On dissolving away the pure zinc entirely by lead chloride solution, the residue showed 8.14 per cent of iron, corresponding pretty well to the formula FeZn_{10} . The fusibility curve showed the melting point rising at the rate of 55° per 1 per cent of iron, attaining a maximum of 755° for the proportions FeZn^{10} , with 8 per cent iron, then falling off to a probable eutectic of FeZn^{10} with Fe, containing 10.15 per cent of iron and melting at 690°. Alloys with less than 6 per cent of iron showed an arrest while cooling at the melting point of zinc, while the alloy with over 8 per cent of iron showed an arrest at the melting point of the eutectic just mentioned.

IRON AND STEEL.

Constitution of Iron-Carbon Alloys.—In *Revue de Metallurgie* for December, Prof. Le Chatelier reviews and criticizes the conclusions of Mr. A. Sauveur's article on this subject, read before the Iron and Steel Institute, and abstracted in this journal for September, 1906, page 356. Le Chatelier points out that the distinction drawn by Mr. Sauveur between the solid state and the liquid state, is contrary to the basic principles of the phase rule, which ignores completely any distinctions between the solid, liquid or gaseous states of one and the same substance. The differences between these three states is solely that of a larger or smaller coefficient of viscosity, simply a question of *more or less*, and the drawing of sharp lines of distinction between them is based on no scientific foundation, and is totally immaterial to the application of the phase rule. There are in reality only two distinct states of matter: the amorphous and the crystalline; and even of these the phase rule takes no account, being concerned only and solely with the question of the *non-miscibility* of different phases, and no person has the right to restrict the well-defined field of application of this rule. The only reservation to be made, in applying the phase rule, is that it concerns systems in equilibrium—a limiting state towards which natural phenomena approach indefinitely under any given conditions. Carbon differs in iron, however, as rapidly as salts in water, and iron is the one solid body in which the phenomena of equilibrium approach their most perfect realization. The application of the phase rule by Roozeboom, in his well-known diagram, is therefore perfectly legitimate and correct, and is unaffected by the erroneous criticisms of Mr. Sauveur. Roozeboom affirms simply that the separation of graphite and of cementite from an austenitic solution follow two distinct solubility curves; he nowhere states that free graphite, in the cooling iron, unites with iron to produce cementite, as is charged by Mr. Sauveur. It is simply a case of misunderstanding on the part of the latter. The experiments of Mr. Sauveur, in which he obtained in the same cooled specimen, both cementite and graphite, are easily explained; one rate of cooling causes cementite to separate, another very slow rate graphite, an intermediate rate both. The preparation of cementite is a state of labile equilibrium, which becomes a state of fixed equilibrium—graphite and ferrite—on slow enough cooling.

Rapid-Cutting Steels.—*Revue de Metallurgie* for December contains a leading editorial from the facile pen of Prof.

Le Chatelier, wherein the work of Mr. Taylor on "The Art of Cutting Metals" is reviewed so appreciatively that some of the pleasant things so gracefully said cannot but sound agreeably to the countrymen of Mr. Taylor. Two paragraphs are as follows:

"It is difficult to comprehend the amount of moral energy required for the following of one line of work twenty-five years—as one may say during the term of an average active human life. There is the secret of American preponderance. Immigration has drained towards the new continent most of the enterprising and active elements of the old world; the sons and grandsons of the first immigrants have preserved a part of these qualities. If, on the one hand, this energy in the service of bad passions has created some grand filibusters of universal reputation, yet it must not be forgotten that in America the same energy is also in evidence in the same degree in men of honor and of industry: Roosevelt, Carnegie, Monsignor Ireland and many others less well known to us.

"Mr. Taylor belongs to this *pleiade* of men of action, who, by the sole force of their wills, have transformed the society in which they live. Since 1900 the industry of machine work has been completely revolutionized in the entire world; this result has been attained by the persevering efforts of one man. It is only justice to proclaim this fact and to express our admiration for such qualities which it would be doubtless difficult for us to imitate on our old and slightly-tired continent. We have, however, like the Romans in the period of the Decadence, still enough appreciation of the best in life to be capable of admiring such characters, as we would admire the finest work of art, and to know how to render homage to them as they pass."

Silicon and Carbon.—F. Wüst and O. Petersen, working in the metallurgical laboratory of the Technische Hochschule, in Aachen, have investigated the influence of silicon upon carbon in iron alloys; their paper is in *Metallurgie* for Dec. 22. The primary object of the investigation was to determine the maximum amount of carbon which could co-exist with definite percentages of silicon, as well as to determine the melting or freezing points and the critical points of such alloys. It was found that increase of silicon was accompanied by a steady decrease of carbon and a nearly steady increase of melting point. Iron and carbon alone possess a eutectic of 4.3 per cent carbon, but the introduction of silicon lowers the per cent of carbon in the eutectic; for any definite amount of silicon present there is a definite percentage of carbon which forms the eutectic. The experimental results are as follows:

Per Cent Silicon.	Per Cent Carbon.	Freezing Point.	(4)	(5)
0.19	4.21	1135° C.	1137°	— 2°
0.51	4.02	1135	1150	15
1.18	3.89	1145	1158	13
1.44	3.79	1185	1165	—20
2.11	3.70	1185	1170	—15
2.63	3.48	1185	1184	— 1
3.28	3.34	1175	1194	19
3.73	3.25	1205	1197	— 8
3.93	3.17	1195	1205	10
4.82	2.95	1195	1220	25
5.18	2.78	1205	1232	27
13.71	1.84	1215	1326	111
18.97	1.12	1235	1422	187
27.18	0.79	1235	1459	224

The authors speak of the increase of melting point caused by the silicon, but the increase shown is less than would be accounted for by the diminishing of the carbon. The melting point of pure iron being about 1,600°, and carbon diminishing its melting point about 100° per each 1 per cent present, the silicon really reduces the melting point of the carbon-iron

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BLAST FURNACE PRACTICE.

Smelter Charge Handling in the Southwest.—The making up and bedding of the charges for blast furnaces is a matter which influences the economy of smelting considerably, and a good deal of attention is paid to it by smelter managers. In practice at these representative works in the Southwest, one of them a large carbon lead and copper smelter, the second, the Copper Queen Reduction Works at Douglas, Ariz., and the third, the smelter of the Greene Consolidated Copper Co., at Cananes, Sonora, Mexico, is outlined in an interesting article by Mr. R. B. Brinsmade in *Mines and Minerals*, January, 1907. At the first works the ore is received in railroad box cars, which run on trestles over the bedding bins. The ore is run out in wheelbarrows over plank platforms, for distribution on the beds below. An ore bed is 80 feet long but narrow, a shipment of the bed's ore being distributed over it by hand shoveling as evenly as the quantity will permit. No attempt is made to bed a self-fluxing mixture, but a different place is provided for each separate class of ore, such as "silicious," "iron sulphide," "carbonate" or "copper," a complete charge being made up by mixing a weighed quantity from several classes. The bin sides have slats, which can be taken out for the entrance of mixing cars over tracks along the level floor. These cars are filled by means of a shovel, weighed and dumped into a steel charge hopper, the latter being of rectangular cross-section with sides sloping to the bottom gate, which opens along the whole length of the charging car beneath. When the 4-ton charge of ore, slag and flux has been dumped into the hopper, it is run into the charging car underneath. This car is fitted with an electric motor and trolley, and after receiving the ore, charge is run under a similar hopper, where the requisite amount of coke is dropped in. It then goes to a hydraulic platform elevator, which lifts it to the feed floor of the furnaces, 32 feet above the tapping floor. To avoid the long drop from the feed floor to the top of the smelting column of the furnaces, a hopper is placed on each side of a furnace, into which hopper the charging car dumps its contents. The gates in these hoppers are then opened, and the charge is thus let into the furnace with very little fall. The practice at the Copper Queen smelter, the ore trains from the mines are run over tracks between the charge pits, the latter being 40 feet wide by 11 feet deep and 800 feet long, having a capacity of 15,000 tons, one longer pit has a capacity of 20,000 tons. For bedding the pit length is attacked in 200-foot sections, and one 300-ton ore train will cover the 800 square feet of area to a depth of 9 inches. The ore is spread evenly by a plough, a framed adjustable wooden scraper moved by an electric locomotive. When one section is nearly full of ore, its average composition is calculated from the samples taken, and enough special ore and limestone is added on top to make the bed self fluxing. An ore pit is emptied by a steam shovel running on a central track along the floor. This shovel lifts the ore into a train of twenty charging cars on a track above, drawn by an electric locomotive. The train is run under hoppers from which the coke is dropped into each car simultaneously. The bedding of the limestone with the ore is stated not to have been a success, and it will soon be handled from bins like the coke. As the coke is on top, it falls below the charge when a charging car is tipped into the furnace. The drop to the smelting column is 6 feet, which causes a good distribution of the feed. In the system in use at the Greene smelter the ore is broken to 2½-inch size, and finally falls onto a conveyor belt, which, by means of a movable tripper can discharge into any one of three conveyors, each of which feeds a bed 400 feet long. One bed is filling while the other is being emptied, the third being held in reserve. The latter conveying belts are discharged by a continuously-moving tripper, which travels forward at the rate of 500 feet per minute and backward at the rate of 250 feet per minute, thus making a round trip in 2.4 minutes, or once for each 8 tons of ore

bedded when running at the rate of 200 tons per hour. When 6,000 tons, or three-fourths of the bin's capacity has been reached, the elements necessary to make the required slag are added, the missing elements, as far as possible, being added in the shape of ore, the limestone being added last and finally the coke. When a bed is completed it is emptied by an automatic shovel, which consists of an endless chain belt on a carriage on rails, which carries buckets that fill themselves, across the whole bed width, thus securing constantly an accurate cross-section of the whole bed from apex to base. By a series of belts the charge is finally brought to the furnace feed floor, where it is automatically delivered to the various furnaces. In addition to the description of the bedding practice the author also gives an outline of the methods of sampling and dealing with the flue dust adopted at the various works. He concludes from general considerations in favor of the method adopted at the Greene Consolidated smelter as giving a more uniform charge.

GOLD AND SILVER.

Wet Crushing and Concentration in Western Australia.

—Mr. R. Hokes in the *Mining World*, Jan. 12, gives a review of metallurgical practice in the Kalgoorlie district. According to him the Diehl process of bromo-cyanidation, as now practiced in the district, where it found its first application, involves the following vital operations: 1. Wet crushing of the ore in stamp batteries with or without amalgamation. 2. Classification of the pulp by spitzkasten and Wilfley tables. 3. Elimination of the concentrate, equivalent to 5 or 6 per cent of the mill product, which constitutes the most refractory portion of the ore. 4. Desulphurization of the concentrate and subsequent fine grinding, amalgamation and cyanide treatment. 5. Fine grinding of the lighter material by tube mills or grinding pans, and the treatment of the resulting slime with bromo-cyanide. The weight of the stamps used is stated to range from 1,100 to 1,275 pounds, dropping on an average 105 times per minute 7½ or 8 inches. The boxes are fed with weak cyanide solutions of 0.01 to 0.04 strength. At the Oroya-Brownhill mill the product passing the 100-mesh battery screen is divided into fine and coarse sand; the latter is reground in Wheeler pans before going to the Wilfley tables. The product of the primary Wilfleys, separated from the heavy concentrate, is passed over eight rows of spitzkasten, the coarse sand from which is fed into tube mills, the fine sand goes to secondary Wilfleys and the slimes to the pulp condensers, ready for the bromo-cyanide vats. The tube mill product is continually returned to the spitzkasten. The author states that the reasons given for using tube mills for sliming with the Diehl process, while Wheeler pans are employed for fine grinding, with excellent results, are not especially conclusive, it being generally contended that these cumbersome machines are better adapted to the production of the very fine slime required and that as they shed less iron than the Wheeler pans, less KCy and BrCy are consumed in the subsequent treatment. There are now 22 mills in use in the district, namely, 10 at the Golden Horseshoe, 6 at the Lake View and 6 at the Oroya-Brownhill. The mills at the Golden Horseshoe are 16 feet 4 inches long by 4 feet diameter; 30 r. p. m.; horse-power required, 30; life of liners of chilled cast iron, six months; charge of imported flints, 5 tons. In the author's opinion the most urgent need in connection with the Diehl process to-day is for an efficient slime table for the recovery of the fine concentrate lost by the Wilfleys. Wilfley slime tables have been tried at two mills, and have been found practically useless for the purpose. The agitation of the raw slime with bromo-cyanide is effected in closed vats, and is completed in about 12 hours. The bromo compound is added an hour or two after the commencement to the amount of ¾ pound per ton, varying according to the value of the pulp. The cost of treatment per ton of slime at the Lake View and Ivanhoe is given as follows:

	<i>Ivanhoe.</i>	<i>Lake View.</i>
Tonnage	90,300	104,500
Labor and salaries.....	\$0.05	\$0.05
Power .....	.07	.06
Repairs and maintenance.....	.02	.02
Assaying and sampling.....	.03	.01
Water .....	.06	.02
Cyanide .....	.43	.26
Bromo-cyanide .....	.53	.38
Royalty .....	.07	.08
Lime .....	.01	.01
Sundries .....	.01	.01
Totals	\$1.28	\$0.90

Filter pressing is also a costly operation, the labor required averaging 22 per cent of the total mill labor forces. The following are the costs of filter pressing at the above two mills:

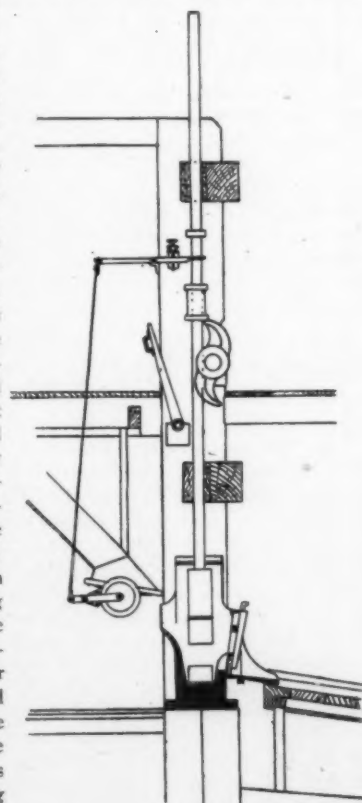
	<i>Lake View.</i>	<i>Ivanhoe.</i>
Labor and salaries.....	\$0.20	\$0.22
Power .....	.16	.05
Repairs and maintenance.....	.06	.02
Assaying and sampling.....	.02	.02
Sundries .....	.02	.01
Total	\$0.46	\$0.32

For other mines the total per ton pressed are 38c., 36c., 32c. and 40c. A patent automatic vacuum filter press is stated to be on trial with thus far promising results. In summing up the metallurgical position at Kalgoorlie, the author comes to the conclusion that whereas the all-roasting process has now been brought to a high state of efficiency the wet-crushing process may yet be bettered, both in regard to extraction and cost. He believes that as things stand, the all-roasting plants may, perhaps, claim superiority, but by the introduction of some means for the more perfect elimination of the finely divided sulphides or slime concentrate, the wet process may yet be able to gain the distinction of undoubted economic priority.

A New Cyanide Plant.—The recently-adopted method of sliming the ore by means of tube mills previous to cyanidation has led to considerable modifications in the design of cyanide plants. An outline of the process to be followed in a modern mill, illustrated by a plan of the mill, is given by Mr. M. R. Lamb, in the *Mining and Scientific Press*, Dec. 29. The ore to be treated has the following characteristics: Gold, \$60.00 per ton; silver, none; concentrate, 5 per cent; free gold, 5 per cent; lime required to neutralize, 10 pounds; cyanide consumed per ton, 1.2 pounds; concentrate value, \$400; the ore is rather softer than ordinary California gold-bearing quartz. The ore goes to the stamps in a size not exceeding $1\frac{1}{2}$ inches. The stamps will weigh 1,600 pounds, five stamps to a shaft, with a cam shaft 7.5 inches in diameter. The plant is expected to treat 140 tons per day, crushing to a maximum of 150-mesh. The stamp stems will be 4 inches in diameter. Crushing will be done in cyanide solution, Muntz metal upon plates being used. The design shows cone classifiers below the battery plates for roughly separating the sand from slime before concentration on vanners. The tailings from the vanners go to a large dewatering cone, the underflow of which feeds the tube mills. The author mentions that the cones will probably be replaced by a Dorr classifier, as the sand can be sent to the mill by the latter with much less water, and thus in better condition for efficient work in the tube mills. The latter are 12 feet in diameter, and are lined with soft iron plates, 1 x 8 inches x 12 feet; the joints are covered with 3-inch angle-iron, 12 feet long. It is expected that this lining will last twelve months. From the mills the pulp will go to cones or to a Dorr classifier, the oversize returning to the mills, while the slime goes to a 6-foot thickening cone. It was hoped that slime tables would be satisfactory for concentration at this stage of the process, but it has been ascertained that a canvas plant is

the only means of extracting all the mineral. With a 10-foot width per ton of dry pulp there would be required a distribution length of 1,400 feet, with a width of canvas of at least 10 feet. Placed on two floors, the space required for the canvas plant would be 17,000 square feet. The remainder of the plant consists of settlers, agitators, which latter are equipped with reaction devices for compressed air, and a slime storage vat, whence the slime is taken to a vacuum filter for washing. The overflow from the settlers and part of the overflow from the filter is sent to the battery sump and is pumped therefrom to the battery supply vat. The solution drawn through the filter passes through a clarifying press on its way to strong and weak gold vats, and from the latter it is pumped through a Merrill zinc dust precipitation press and returned to the battery sump. The slime cake is first washed with battery sump solution and then with water enough of the latter being used to make up for the loss by evaporation and as moisture in the residue. The labor in a mill such as outlined will consist of one battery man, one concentrator and tube mill man, one canvas man and one cyanide man, the cost of which, together with superintendence, will be about 55 cents per ton milled with a 20-stamp mill. The total working cost is expected to be well below \$2.50. When the mill is increased to 40 stamps the labor will be increased by one battery helper and one canvas man per shift, making a total of 36 cents per ton milled and bringing the cost to less than \$2.00 per ton milled.

Some Accessory Stamp Mill Appliances.—Stamp milling in the large mills of the Witwatersrand has been brought to a high state of efficiency and the recovery figures obtained and the stamp duty are probably unsurpassed anywhere in the world. In a paper read before the Chemical, Metallurgical and Mining Society of South Africa, published in the November issue of the journal of that Society, Mr. G. O. Smart gives some data concerning the details of construction of stamp mill machinery in use at the Simmer and Jack Proprietary mines. He illustrates the arrangement of driving the Challenge feeders as represented in the accompanying diagram. It will be noted that the rocking bar or feeder arm is removed from the top of the mortar box and the ore chute, and is placed on the king post under the top guide block. Power to drive the gear is transmitted by means of a manila rope $\frac{1}{2}$ inch or $\frac{3}{8}$ inch in diameter. The center box, fulcrum bracket, the connecting rod, the springs, etc., are no longer required, and a wood bearing is placed on the horizontal shaft which can be adjusted to act as a slight brake. This construction helps to steady the shaft, and, by keeping the teeth of the



STAMP MILL CONSTRUCTION.

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level wheels up to their work, effectively prevents any backlash. The author claims the following advantages for an arrangement of this kind:

1. The feed is adjusted from the cam platform by the amalgamator, who is testing the stamps, without his having to go downstairs and around to the feeder platform in order to make the adjustment. 2. When the center tappet is set, the box is fed by the man that works on the cam platform by an occasional pull on the $\frac{1}{2}$ -inch rope instead of having a man filling up the box from the feeder platform. Furthermore, the transmission of power by means of a small rope gives a very easy and steady movement to the gear instead of the usual hard knock and jar, and thus the wear and tear on the feeder parts is reduced to a minimum. The removal of the feeder arm from the top of the mortar box allows of a wood housing being put around or a mortar with a higher top may be used without having to raise the bottom guide blocks, and thus take them further away from the stamp heads. With a deeper top to the mortar box, longer heads, or larger shoes and dies, can be used to increase the weight of the stamps. The author also finds the hydraulic press a great convenience for removing the broken stem ends from the heads. The machine is set up inside of the mill and one man can remove the broken stem end from the stamp head in a few minutes. The experience of the author in this respect was confirmed in the subsequent discussion of the paper by Mr. J. P. McKeown, who estimated that the hydraulic extractor would save 60 per cent of the expense usually incurred in this operation. The author also finds that a solution of hydrochloric acid of 1.6 per cent, or about 1 in 20 of the commercial acid, makes a very good substitute for 0.9 per cent cyanide solution when applied only to the parts of the plate where some discoloration or film was apparent, and when used at the end of the dressing operation, just before water was again turned over the plate, so that the contact was as short as possible. He always found a value of from 6 to 8 dwt. of gold in solution in the first flow of water coming over the table after dressing, and a steady 0.02 dwt. was returned as the value in the clear water overflow from the slimes collectors. Since stopping the use of cyanide in the mill altogether and using hydrochloric acid, only when required, he has never had more than traces of gold returned as the value of the clear water from the slime collector.

RECENT METALLURGICAL PATENTS.

ZINC.

Zinc Furnace.—William Lanyon, of Iola, Kan. (839,160, Dec. 25, 1906), patents details of construction of a zinc furnace with the object to obtain a gradual and perfect combustion of the fuel, "thereby producing not only economy in fuel, but at the same time a more uniform and desirable character of combustion and consequent steadiness of temperature in the retort-furnace chamber, which results are highly essential for the proper volatilization and distillation of the metallic zinc, and likewise for the saving of the retorts or muffles from destruction usually resulting from spotted, irregular and uncontrollable heats." The fuel is taken in at the lower end or bottom of the furnace chamber, where the fuel is ignited, and the fire and heat thus obtained naturally pass upwardly through the retort chambers, strike against the furnace roof or arch, and are deflected thereby downwardly, and the flame and heat are withdrawn from outlets at the bottom of the furnace. This arrangement, together with the admission of air for combustion at the proper points, produces a condition whereby the air and gases are very easily mixed and intermingled. This naturally results in an easily regulated perfect combustion. The special means by which this result is obtained are well indicated by the ninth claim, which reads as follows: "A zinc furnace, constructed with a center wall,

there being a flue centrally arranged in said center wall, means whereby air and gas are delivered into the ends of the furnace through the base of the center wall, inlet openings from the exterior of the furnace through the top of the center wall at the ends of the furnace, inlet openings formed through the end walls of the furnace, and means whereby the air and gas during combustion are led upward between the retorts in the ends of the furnace and downward between the retorts at the center of the furnace, and the products of combustion discharging through the flue in the center wall."

Complex Sulphide Ores.—Zinc and other metals like nickel, cobalt, manganese, copper and cadmium are extracted from complex ores by the following method of W. G. Rumbold and G. Pitchin, of London, England (832,341, Oct. 2, 1906). The ores are crushed to 40-mesh per inch and subjected to an oxidizing roasting until the sulphur is removed as far as possible. The ore is then treated with a solution consisting of about 1 per cent of ferric sulphate, ten parts, by volume, of commercial sulphuric acid and a small proportion of sodium chloride, the latter ingredient varying in quantity according to the composition of the ore to be treated, but in no case being sufficient to dissolve the silver chloride which may have been formed. These ingredients are dissolved in 100 parts of water. The effect of this treatment is that all the sulphuric acid radicals in the solvent are used in dissolving zinc compounds or other metallic compounds from the ore without the production of ferrous compounds, and a neutral solution is obtained which is entirely free from salts of iron. "The results, therefore, attained by this invention are the production of a pure and white zinc oxide suitable for paint and other commercial and metallurgical uses from complex sulphide and oxidized ores containing zinc, and the recovery also as by-products of any copper, manganese, nickel or cobalt there may be in such ores." The idea of using a composite solvent consisting of small parts of ferric sulphate and sodium chloride and a larger part of sulphuric acid, is that the oxides, sulphates and carbonates of zinc, copper, manganese, etc., are dissolved by the ferric sulphate, which is thereby decomposed but at once regenerated as long as there is free sulphuric acid in the solution. Sodium chloride is added in order to yield hydrochloric acid by reaction with sulphuric acid; the hydrochloric acid dissolves such portions of the metallic compounds which would otherwise not be attacked. The solution in which the metallic values are thus dissolved is then treated as follows: The saturated solution is first treated with zinc dust, by which copper, arsenic, antimony, lead, bismuth, cadmium and tin are precipitated. It is then filtered and treated with an oxidizing agent to oxidize and precipitate the manganese as hydrate. For this purpose potassium and sodium permanganate are most suitable, and when they are used the manganese in solution, together with that in the permanganate, is precipitated as manganese dioxide or in the form of a hydrate. The nickel and cobalt are precipitated as the hydrated oxides from the solution by the proper addition of bleaching powder. The solution is finally treated with just sufficient ammonium hydrate to decompose the zinc salts in solution, and hydrate oxide of zinc is precipitated, which is separated by filtration, washed and ground.

LEAD.

Alloy.—G. F. Allen (839,444, Dec. 25, 1906) patents a composition of lead-copper-nickel alloy which is claimed to have greater tensile strength than other soft metal alloys and to be much less subject to corrosion. The proportions in which the metals are used vary according to the nature of the lead used, and are from one-twentieth of 1 per cent to $4\frac{1}{2}$ per cent nickel, and from one-twentieth of 1 per cent to $4\frac{1}{2}$ per cent copper, and the balance lead, and preferably soft lead.

PRECIOUS METALS.

Treatment of Pyritic Ores.—A patent of W. Blackmore and A. Howard, of London (839,451, Dec. 25, 1906), refers to

the removal of iron pyrites from pyritic ores containing gold and silver. The ore is pulverized to about a 30-mesh, and is then oxidized in a furnace at a temperature of about 800° F. by passing steam and air in regulated quantities through the furnace. The steam is added to modify the oxidizing action of the air and in such proportion as to prevent excessive local action. The effect of this treatment is to convert the iron pyrites into either a normal or basic sulphate or a mixture of sulphate with oxide of iron, and the operation is regulated with a view to the production of a maximum proportion of sulphate. The roasted ore is then leached with a 5 per cent solution of sulphuric acid, and thereby not only the iron but also the copper, cobalt and nickel are dissolved. After separation from the liquor the solid residue containing the gold and silver are treated by suitable extraction processes. The acid liquor necessary for solution is obtained from the sulphurous gases evolved during roasting.

Cyanide Process.—H. B. Goetschius (840,840, Jan. 8, 1907) endeavors to obtain a more complete extraction of gold and silver by a cyanide solution with greater rapidity by the following means: Besides accessory apparatus and tanks there is a solution tank and an ore tank. In the solution tank compressed air is dissolved in the cyanide solution under pressure and the solution is then forced through the ore (which rests on a false bottom in the ore tank) against a back pressure, so that the original pressure is maintained. The pressure is then released, whereby the air is disengaged from the solution and the bubbles of air thoroughly agitate the ore. Finally, the pressure is increased again slightly above the original value in order to redissolve the disengaged gas together with any films or bubbles adhering to the particles of ore. It is, of course, understood that the oxygen in the air is required together with the cyanide solution for thorough extraction.

Modified Cyanide Process.—John A. Just (841,983, Jan. 22, 1907) endeavors to enlarge the scope of the cyanide process to make it applicable to the treatment of such ores which contain substances which with ordinary treatment would retard the extraction and consume the cyanide. For this purpose he subjects the ore to a preliminary treatment, by means of which substantially all these deleterious substances are removed. The ground ore is subjected to the following treatment, in order to render the objectionable minerals in the ore soluble and then to remove the soluble salts formed by leaching and washing. The cleaned sands are then ready for the regular cyanide treatment. The ore to be treated is first reduced to a suitable mesh and dilute sulphuric acid is added thereto sufficient to cover the ore, about 3 parts of sulphuric acid of 1.25 specific gravity to 1 part of finely ground ore or tailings. An oxidizing agent or oxygen salt (such as manganese, dioxide, sodium nitrate) is preferably added to the sulphuric acid and the mass heated. According to the nature of the ore more or less strong acid is required or more or less oxidizing agent should be employed, and also the time of heating required to render the extraneous minerals soluble or inert depends upon the amount of such constituents in the ore. Silver present in quantity in the gold-silver ores is thus removed and goes into solution, while the porous and readily soluble gold will remain in the sands, to be extracted in the subsequent process of extraction.

Chlorination Process.—W. V. Lander (841,328 and 841,329, Jan. 15, 1907) modifies the chlorination process as follows: The ore is treated within a long chamber consisting of a series of riffle pipes following each other in cascade form. At one end of the long chamber both ore and chlorinated water are introduced, which are mingled together and proceed along the chamber as one stream, being agitated by the riffle ridges and still further agitated by falling in cascades from one riffle plate to the next. If the chlorinated water entering the chamber carries chlorine in sufficiently concentrated solution, an atmosphere of chlorine will be thereby maintained in the riffle pipes. The presence and maintenance of this atmosphere

of chlorine is of value, since it regenerates and reinforces the solution during the progress through the chamber. The insoluble portions of the mass of metal containing earth or rock are detained by the riffle plates and retarded and classified according to their size, specific gravity, etc. The grooves between the riffle ridges gradually fill up with these insoluble concentrates.

IRON.

Iron Reduction in Rotary Kiln.—Attempts to reduce iron ore in a rotary kiln into which the ore mixed with carbon is fed at one end, meeting in the kiln a high-temperature flame from the other end, are not new, but it is known that former trials of this kind were unsuccessful. The carbon mixed with the ore burned away before it reached the lower part of the kiln and did not act as a reducing agent; very little of the ore was reduced to metallic iron, although a large portion of it was reduced to ferrous oxide. Since the carbon burned near the end where it was fed into the kiln, and where the products of combustion left the kiln, there was a large loss of heat by the gases leaving the kiln. Carleton Ellis (839,126, Dec. 25, 1906) has again taken up this problem, with a special view of reducing finely divided ores of pure magnetite or magnetic concentrates without briquetting them. In order to avoid the results of former experimenters sketched above, he points out that it is necessary to subject the ore to a sufficiently high temperature and at the same time to do this in a reducing atmosphere. This is accomplished in the manner already sketched in an abstract of a former patent of the same inventor (our Vol. IV., page 74) by the employment of two flames of different characters, the one carrying an abundance of air, and therefore having a high temperature, and the other having insufficient air or no air at all. For the attainment of the reducing conditions the latter flame is interposed between the high temperature flame and the ore. Another method of securing the reducing conditions is to enter carbonaceous material at some point in the path of the travel of the ore, at a point near the final zone of reduction. By means of the hot products of combustion, which should contain carbon dioxide only and no carbon monoxide, the cold ore is preheated when entering the kiln.

Briquetting.—In our Vol. IV., page 510, we give an illustrated description of the Gröndal process for briquetting finely divided iron ores, which is in successful operation in various plants, especially in Sweden and Norway. It is evidently to this process that the patent of F. J. Bergendal (832,358, Oct. 2, 1906,) refers. Since the principles were fully dealt with in our former article, it must suffice to state that this patent refers to details of construction.

Combined Bessemer Converter and Open-Hearth Process.—To produce steel very low in phosphorus and sulphur, and of an exact desired low silicon content, by means of the acid Bessemer converter process, very pure ores are required. H. H. Weaver and G. E. Thackray (837,598, Dec. 4, 1906) try to make the acid Bessemer process of greater general application by combining it with an open-hearth furnace in the following way: From a series of blast furnaces handling ore of no particular selection, comparatively irregular quantities of pig iron are charged into a receiver or mixer containing approximately one or more hundred tons of molten metal. At the same time pig iron of about the same quality is introduced into an open-hearth refining furnace, which is provided with a basic lining of such a character as to aid in the elimination of phosphorus, sulphur and silicon. Basic additions may also be made to the charge in this furnace, so as to eliminate almost all of the silicon, from 80 to 100 per cent of the phosphorus and a reasonable portion of the sulphur. This refined metal is then added to the contents of the large receiver or mixer mentioned above, yielding a bath so constituted in sulphur, phosphorus and silicon that it can be treated directly in an ordinary acid Bessemer converter.

BOOK REVIEWS.

PRODUCER GAS. By J. Emerson Dowson and A. T. Larter, 8vo., 295 pp., 73 illustrations. Price, \$3. Longmans, Green & Co.: London and New York.

A splendid treatise by the mentor of the producer-gas power industry. For thirty years Mr. Dowson has improved gas producers and gas engines, exhibiting in 1881 at the Paris exhibition his first complete apparatus, and since then being continuously immersed in this rapidly improving subject. Of the fifteen chapters, three, covering 60 pages, are on the theory of producer gas, and in them we find this branch of the discussion most clearly and scientifically set forth.

An especially commendable, withal surprising feature (Mr. Dowson will pardon us, we feel sure, for saying "surprising"), is that the authors have dropped pounds, ounces, cubic feet and Fahrenheit degrees, and come out squarely on the metric system. Appreciating the courage it took to do this, in Great Britain, we heartily congratulate the writers on their broad-minded position and the excellent result it must exert on English technical literature, in general, and has exerted on this treatise, in particular.

Eight chapters (157 pages) deal with the technique of construction and operation of producers and properties of the gas. These are most practically and lucidly written, showing all through that the treatment is by one who is master of the subject "from a to izzard."

We take issue with the authors only on two points, in this part of the work, one concerning the calorific power of a fuel or gas, the other the manner of calculating its calorific intensity. If a fuel or gas is consumed in a calorimeter, the water formed is condensed to liquid, and a considerably higher calorific power is observed than it is ever possible to obtain in practice, where this heat of condensation is never utilized. We believe that the calorimeter value should always be corrected to the practical value, by subtracting this latent heat of condensation, and only this practical value charged against any furnace using fuel or credited to any furnace producing gas.

Dowson and Larter believe that in calculating the heat balance sheet for a gas producer or in calculating its efficiency, the *gross* calorific powers of the coal and gas should be used. If the authors could have cited any single case in which the products of combustion are cooled to such a point that this latent heat in question is usefully applied in the apparatus, they would have had justification for saying that the *gross* calorific power "will be useful for certain purposes." But there are no such cases, in practice, and therefore the *gross* calorific power is a practical delusion, an unapproachable *ignis fatuus* which has no useful or justifiable place in practical heat calculations. Its use may lead to a very serious distortion of the heat balance sheet, as was explained by Dr. J. W. Richards in this journal, May, 1905, pp. 187-9.

The other point we criticize is the rather clumsy way in which the calorific intensity of a fuel is calculated, by a series of approximations, instead of by the exact method using algebra, involving nothing harder than the solving of an equation of the second degree. True, Damour of Paris uses this arithmetical method, and is also followed by Queneau, and possibly it is more easily understood by practical men who know little or nothing of algebra, but the average technologist knows enough mathematics to use and apply the more elegant and more expeditious algebraic solution. (See also above reference.)

The four chapters (67 pages) on gas engines and gas-power plants are above criticism. No better discussion, in the limited space available, has appeared anywhere.

Altogether, the book is highly commended as the most scientific and generally reliable work on this subject in the English language.

Niagara Falls Power.

In accordance with the Burton bill, which limits the amount of water to be taken from the American side of the Falls to a specific number of cubic feet per second, and restricts the amount of power to be imported from the Canadian side into the United States to 160,000 hp., Secretary Taft has now made the following decision as to the division of the total amount among the different power companies.

The total of 160,000 hp. imported from Canada is divided as follows: "To the International Railway Co., 1,500 hp.; to the Ontario Power Co., affiliated with the Niagara, Lockport & Ontario Co., of New York, which transmits power to Lockport, from Lockport to Buffalo, and from Lockport by way of Rochester to Syracuse, 60,000 hp.; to the Canadian Niagara Falls Power Co., 52,500 hp., and to the Electrical Development Co., 46,000 hp.

The International Railway Co. had asked for a permit for 8,000 hp., the Ontario Power Co. for 90,000, the Canadian Niagara Falls Power Co. for 121,500, and the Electrical Development Co. for 62,500. Thus none of the companies got nearly as much as they desired.

In the matter of diversion of water on the American side, Secretary Taft decided that the Niagara Falls Power Co. be permitted to use 8,600 cubic feet per second, the Niagara Falls Hydraulic Power Co. 6,500 cubic feet a second, and the Erie Canal 400 cubic feet a second.

Secretary Taft states he has reached the conclusion "that with the diversion of 15,500 cubic feet on the American side and the transmission of 160,000 hp. from the Canadian side, the scenic grandeur of the falls will not be affected substantially or perceptibly to the eye."

A committee of three has been appointed by Secretary Taft to report on the possibility of harmonizing the commercial buildings at Niagara, particularly the power plants, with the natural beauties.

The power permits will be effective for three years—the life of the Burton bill. If at the end of six months from the time of actual operation under the permits, no depreciation in the beauty of the Falls is shown, Secretary Taft is empowered to issue permits for additional power.

Multiple Scale Switch.

Ever since the invention of multiple scale voltmeters there has been great need for a simple device to protect them against injury as result of wrong connections. Every one knows how easy it is to connect (by mistake) a high potential to the low reading side of a voltmeter, the result being at least a bent pointer and frequently a burnt-out coil. In addition valuable time is lost, to say nothing of the annoyance.

The American Instrument Co., recognizing the necessity for some such device, provide for it in the following way: All of their portable voltmeters which have more than one range are provided with a "multiple scale switch," which makes it practically impossible to injure the instrument by careless connection or through ignorance. This switch is shown in the adjoining illustration. It is placed on the instrument where it is easy to use and operate.

Normally the indicator stands at "open" as shown. Connection is made to the one pair of binding posts no matter what range is wanted; then the button is turned till the indi-



cator points to the range desired and the readings are made. The switch is securely held in position for the required range until the operator is through, then either by pushing a button or closing the lid of the instrument it is released, and flies back to the open position. Thus the switch always stands at "open" when the instrument is not in use, and it is impossible to use the low range without connections having first been automatically made to the higher ranges. Consequently the operator is forced to think and see exactly what he is doing, thereby affording the best protection conceivable against carelessness or absentmindedness. Mr. James G. Biddle, 1114 Chestnut Street, Philadelphia, is the general sales agent for the company.

Filter Presses for Slimes Treatment.

During the past years we have repeatedly recorded new developments in the treatment of slimes in the cyanide process, relating especially to regrinding in tube mills and to the use of filter presses for separating the slimes from the cyanide solution in which the precious values are dissolved. This method apparently originated in Western Australia, but now gradually conquers the world of good metallurgy and finds especially growing application in this country.

The adjoining illustration shows a 5-ton filter press, built by

closed delivery channel on the other hand saves a little time in the operation of the press, there being no cocks to open and close each time the press is filled, and where the final solutions are strained through a clarifying press to remove all trace of solids, the closed delivery type may be considered desirable.

Attention may be called to the arrangement of channels in this press, which are such that the treating solution or wash water must pass through the cakes from one side to the other in the most direct and uniform manner, and the drying of the cakes is effected with complete satisfaction by passing compressed air through the press.

Another type of filter press, built by Messrs. William R. Perrin & Co., is for the separation of the precipitates in the chlorination process. This type has been adopted as the standard by the chlorination plants in Colorado and elsewhere. With this type of press filter paper is used in conjunction with filter cloths, and the paper is stripped off and burned to recover the values. The cloth is eventually burned for the same reason. These presses are universally of the closed delivery type, and no trouble is experienced on account of the defective filtering surfaces when the presses are fitted up with ordinary care.

The same form of press which is used for the chlorination process is recommended for the separation of zinc dust precipitates in the cyanide process.



FILTER PRESS FOR TREATING SLIMES BY THE CYANIDE PROCESS.

Messrs. William R. Perrin & Co., Forty-sixth and Loomis Streets, Chicago, Ill., for the Echo Mining Co., Navajo, Cal. Another one of these presses has been furnished by the same manufacturers to the Horseshoe Mining Co., while a $3\frac{1}{2}$ -ton press has just been sold by them to the Vindicator Consolidated Gold Mining Co., of Denver.

This press embodies the best features of the foreign type of press which is so successfully used for the treating and washing of slimes. This press is of the kind known as "flush plate and division frame type," in which the plates are flat without recesses, and the chamber is formed by a division frame, the width of which determines the thickness of the cake. In this press all feed and exit channels are formed in projecting lugs, and are made tight by means of rubber rings set into the metal surfaces, thus allowing the use of cloths that do not have to be perforated to match the feed and exit channels, in this way saving a great amount of time and inconvenience in setting up and admitting of a much tighter press.

The exit is provided through a drip cock at the bottom of each plate, or is arranged to pass through a closed channel extending through the press. The former plan has the advantage of locating a defective cloth on the press, and enables that particular plate to be cut out by closing its particular drip cock, through which a cloudy solution would be passing. The

Messrs. William R. Perrin & Co. also build a round-pattern center-feed type of filter press of the simplest construction for general quick separation of solids held in suspension and for drying the same into solid cakes.

Fused Quartz for Pyrometer Tubes and Other Uses in Chemical and Metallurgical Engineering.

Cracking from quick temperature changes is caused in glass, porcelain and fire clay, because those materials expand or contract as they are heated or cooled with the result that a difference of temperature between the surface and interior or any two parts of one piece produces internal stresses that the material is not strong enough to resist. It so happens that pure silica has an exceedingly small coefficient of expansion, and being free from internal strain, no matter what extremes of temperature are developed in one piece, it has naturally no tendency to crack from either heating or cooling.

Silica is now melted in the electric furnace and shaped into crucibles, muffles, dishes, tubes, plates and pipes, and such articles made of the pure silica do not crack, even with the most sudden and violent temperature changes.

It is almost startling to see articles of this material heated to a red or white heat and plunged into cold water without the development of even a crack. Similarly it may be taken cold and plunged into molten metal without damage to it.

According to the recent investigation of H. D. Minchin (*Phys. Review*, January, 1907) the coefficient of expansion of fused quartz is uniform from room temperature to the highest electric furnace temperature used in the experiments, and amounts to 44.9×10^{-6} . This means that fused quartz expands 1 part in 2,230,000 parts for 1°C , or 1 part in 4,010,000 parts for 1°F . For comparison we give some figures from Trautwine's pocketbook. A glass tube expands 1 part in 214,200 parts for 1°F ; i. e., its expansion is almost 20 times larger than that of fused quartz. Black marble (which is about that substance in Trautwine's table which has the smallest coefficient of expansion) expands 1 part in 405,000 parts per degree F; i. e., its expansion is still 10 times greater than that of fused quartz.

Why does a glass vessel crack when it is, for instance, suddenly heated from the outside? Because the temperature of the outside surface rises more quickly than the temperature of the inside surface, resulting in a difference of expansion of the glass outside and inside. This difference of expansion or this non-uniformity of expansion—which sets up stresses in the glass resulting in a crack—is reduced 20 times if fused quartz is substituted for glass. This figure is a good illustration of the enormous superiority of fused-quartz articles over glass articles for all purposes where sudden changes of temperature are unavoidable.

This fused silica softens slightly between 1400° and 1500°C . (or about 2550 and 2730°F). Its melting point is above 1500°C . It is of good body, hard and strong. The inside surface of most shapes is glassy, and the other surface quite smooth.

Tubes may be had of numerous diameters from 1-16 inch to 1 inch inside measurements, and up to 5 feet long, and even larger tubes in shorter lengths. These tubes made with closed ends should bring back into use many a Le Chatelier pyrometer which has been laid away because of the great expense of continually buying porcelain tubes to protect the thermocouple wires. Those porcelain tubes that will stand the very high temperatures are necessarily somewhat high priced and they are prone to crack without warning and result frequently in a spoiled couple as well as a broken tube.

On the other hand, the tubes of fused silica give no such difficulty. Not the least interesting feature is that the fused silica tubes are less expensive than the porcelain.

It is the very reasonable price at which the articles of fused silica are being introduced into this country by the Wilson-Maehlen Co., 110 Liberty Street, New York, that insures wide interest in and usefulness for the material. Fused silica as they supply it is milky white and not transparent.

It may be of interest to many to know that they may now use their thermoelectric pyrometers to make temperature determinations on molten metals by using the fused-silica pyrometer tubes which may be inserted right into the metal, the tubes being so thin that very little time is lost in the heating of the thermocouple to the temperature of the melt.

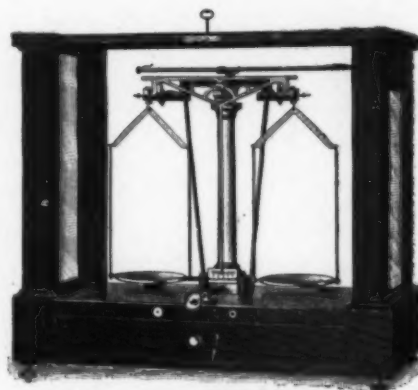
But this new and comparatively cheap fused quartz will undoubtedly also find much favor for many other purposes, for instance, in form of crucibles, bed-plates for muffle furnaces, etc., for which purposes fused quartz has distinct advantages.

New Balance.

The adjoining illustration shows a new quick-acting, short-beam and highly sensitive analytical balance for scientific use, just placed on the market by Messrs. Voland & Sons, of New Rochelle, N. Y. It embodies all the latest improvements

which have been introduced by this firm in their twenty years of experience in the design of analytical balances.

The balance is mounted in a French polished mahogany glass case with front counterpoised sliding-frame and glass top. In the illustration the front and rear frames are removed



SCIENTIFIC-ANALYTICAL BALANCE.

to permit a better view. The case is 21 inches long, 20 inches high and 10 inches wide.

The beam of the balance is $8\frac{1}{2}$ inches long and is divided into 100 parts on either side. The beam is of truss construction and is made of hard metal of the manufacturers' own composition. The rider has a clean sweep over the beam and can be used from the zero point. The knife edges are made either of agate or steel. All bearings are of agate.

The pans measure 4 inches in diameter and the balance is sensitive to 0.1 milligram, with its full capacity of 500 grams in each pan, and it may be said that this rating is quite conservative.

Notes.

New York Section American Electrochemical Society.—

At a meeting held on Jan. 30, at the Chemists' Club, Mr. Woolsey McA. Johnson, metallurgist of the Tri-Bullion Smelting Co. presented a very interesting paper on the electro-metallurgy of zinc. Besides electrostatic and electromagnetic methods of concentration he covered the possibilities of both electrolytic and electric furnace methods for zinc production. The paper was a very able and conservative statement of the present situation, and was discussed at length by a number of experts in zinc metallurgy. We hope to give a more extended review both of the paper and of the discussion in our next issue. At the next meeting, to be held on Feb. 26, Prof. C. E. Lucke, of Columbia University, will lecture on the relative cost of power from water, steam, gas and oil.

Gas Producers.—A large order for gas producers was awarded to the Wellman-Seaver-Morgan Co., of Cleveland, by the United States Steel Corporation. It calls for 64 Hughes mechanically-poked continuous gas producers for their Duquesne steel works. These producers are to be operated by electric motors, and are equal in gas producing capacity to 160 hand-poked producers. The chief advantages claimed for the Hughes mechanical producer are that they save the labor of hand poking, give a better quality and a more uniform supply of gas, and in battery require less room than the hand-poked type of producer.

Tantalum.—While the tantalum lamp of the Siemens & Halske Co.—the appearance of which not yet two years ago marked such an important advance in electric incandescent lighting—is apparently already beaten by the new tungsten lamp, new applications are being found for tantalum. According to *The Engineer* (London) Siemens & Halske intend

to manufacture tools and other articles out of tantalum alloys, and the German patent, No. 167,217, granted to this firm, means perhaps the end of an extensive, and since the twentieth year of the last century, vigorous industry. The tantalum pen is said to have a great resistance against chemicals, to be much harder and more elastic than the steel pen, and on account of this hardness and elasticity to be indestructible. It exceeds in elasticity the well-known gold nib of the fountain pen, and so these two kinds of writing pens will soon be supplanted, if they succeed in manufacturing tantalum metal at an acceptable price. The fundamental patent of von Bolton for making pure tantalum metal in the electric furnace was noticed on page 238 of our Vol. IV.

The Frederick Pearce Co., 18 Rose Street, New York City, who purchased, about a year ago, the business carried on by the Willyoung & Gibson Co., have now provided the requisite facilities in the way of space and equipment for the progressive development of electric measuring and scientific measuring instruments. This company will also pay special attention to X-ray and electrotherapeutic apparatus.

Metallic Manganese.—Messrs. Geo. G. Blackwell, Sons & Co., of Liverpool, announce that after experimenting for two years they have developed a new method of producing a high-percentage metallic manganese, which they are in a position to place on the market at a comparatively low price.

Ferro-Alloys.—The Electrometallurgical Co. has been formed for the purpose of manufacturing ferro-alloys, and for the present time especially low-carbon ferro-alloys like ferro-chrome, etc. The interests of the company are closely identified with those of the Union Carbide Co. The manufacture will be carried out at Niagara Falls.

Ferro-Titanium.—The Titanium Manufacturing Co., backed by prominent New York capitalists, has bought a piece of property at Niagara Falls covering 4 acres. Electric power will be obtained from the Ontario Power Co. The object is the manufacture of ferro-titanium. The company is presumably the outcome of the researches of Mr. Rossi.

Maps of Niagara Power Districts.—We have received from the Ontario Power Co., of Niagara Falls, maps of their power districts in a handsome cloth folder. There are five maps. No. 1 is a general map of the transmission lines of the Ontario Power Co., from Syracuse, N. Y., to Hamilton, Ont., and to Buffalo, N. Y.; it also shows the proposed extensions. No. 2, referring to Eastern Ontario and Western New York, is a general map of the Niagara frontier. No. 3 is a map of the Welland Canal; No. 4 of Niagara Falls and vicinity; No. 5 of Buffalo, Depew and West Seneca.

Enamelled Iron Pans.—The Stuart & Peterson Co., of Burlington, N. J., have placed on the market a line of oblong evaporating pans for chemists' use. These pans are of porcelain-lined iron with a raised edge to protect the porcelain. They are manufactured in three sizes, from 29 to 36 inches in length by 20 to 27 inches in width, with depths ranging from 2½ inches to 4 inches. They are particularly adaptable for drying chemicals in works and laboratories. When desired the pans are provided with heavy iron stands.

Gas Producer.—Circular No. GP-1 of the Wellman-Seaver-Morgan Co. gives a fully illustrated description of the Hughes continuous gas producer.

The Western Electric Co. has recently issued a well illustrated pamphlet describing their Hawthorne works for the manufacture of power apparatus, at the extreme west of the city of Chicago.

The Forter-Miller Engineering Co., of Pittsburg, have sent us their large catalogue of special apparatus and machinery for iron and steel plants. It includes concise descriptions of the Forter water-seal gas producer, the Forter feeding device for gas producers, the Forter charging machine for annealing furnaces, several types of Forter reversing valves, various

types of welding furnaces, billet furnaces, annealing furnaces, crucible furnaces, open-hearth furnaces, blast furnaces, etc. All descriptions are illustrated by very clear diagrammatic drawings showing the principles of the design.

Pyrometers.—The latest catalogue of Messrs. Edward Brown & Son, 311 Walnut Street, Philadelphia, is specially interesting for the large amount of useful information on various types of pyrometers and their uses in the industries, especially in iron and steel plants, coke ovens and gas works, glass plants, brick, clay and emery-wheel works and chemical factories. Not only the manufacturers' own well-known hot-blast pyrometer, quick-acting platinum pyrometer, water-current pyrometer, etc., are described and illustrated, but the catalogue covers also the important types of other inventors, like electric resistance pyrometers, the Le Chatelier thermo-electric pyrometer, the Siemens water pyrometer, the Féry radiation pyrometer, the Uehling pneumatic pyrometer and others. The catalogue is concluded by illustrated descriptions of revolution indicators, pressure gauges, etc.

Fans.—Catalogue 200 of the American Blower Co., of Detroit, Mich., deals with their disc fans for all ventilating purposes.

Calendars.—The 1907 calendar of the National Carbon Co., of Cleveland, Ohio, has the picture of quite a pretty young lady, holding a mask in her hands, evidently as an excuse for the somewhat fantastic, but decidedly striking make-up of hair and dress. Between the calendar sheets of the different months descriptive sheets are inserted, dealing with various products of this company, as primary cells, dry cells, carbon brushes, arc lamp carbons, etc. The 1907 calendar of the Laclede Fire Brick Manufacturing Co., of St. Louis, is a third revised and enlarged edition of their well-known picture symphony on Satan's furnace equipment. It reminds the writer of a recent visit to a smelting plant, where Laclede fire-brick was used very successfully and to a large extent. Somebody remarked there, and the others consented, that it was surely hot enough to make any man pious. We hope that the Laclede Co.'s calendar, besides its value as an advertisement of their goods, will have the same effect.

Welding of Iron.—The American Ferrofix Brazing Co., of Philadelphia, announce that they have secured the general sales agency for the Harris Calorific Co., of Philadelphia, manufacturers of apparatus for brazing and welding by means of the blow-pipe. As special advantages of this method in its latest improvements by the Harris Calorific Co., it is stated that flaws, imperfections, sand holes and cracks in castings can be perfectly filled in without the objectionable hard scale formed by the electric arc. Lugs and projections can be welded on more securely and economically than by riveting, and, when used in conjunction with "Ferrofix" the brazing of cast iron can be accomplished in an eminently satisfactory manner. The apparatus is extremely simple in construction, and does not require such skilled attention, nor consume such an amount of power as the electric arc.

Carbon Tetrachloride and Sulphur Chloride.—Electrolysis of common salt yields caustic soda and chlorine. Caustic soda is sold at a good price, while there is some difficulty in working up the chlorine into commercial products which bring a good price. It is mostly worked into bleaching powder, but the supply having been larger rather than the demand, there has not been much profit in its manufacture in recent years. Naturally attention was directed to the manufacture of other chlorine products, and it is known that among others the Acker Process Co., in Niagara Falls, have made extended researches in this direction. Two of their main chlorine products are carbon tetrachloride and sulphur chloride. From announcements of the National Aniline & Chemical Co., 100 William Street, New York City, who are selling agents of the Acker Process Co., we gather the following notes: Carbon tetrachloride is an excellent solvent, and dissolves oils, fats,

and innumerable other products. It is not acted upon by either strong acids or alkali. Carbon tetrachloride, as an extracting medium, has found wide application in the extraction of fats and oils from oil seeds, oil cake, animal tankage, wool, wool and cotton waste and other oil and fat-bearing materials. They are extracted by carbon tetrachloride with the highest degree of purity, absolutely free from residual solvent and contaminating odor, taste or "chemical smell," and the extracted materials may be produced absolutely free from solvent and with no odor or taste imparted to them. It is a very excellent cleansing agent, as it does not affect in the least the most delicate colors or fabrics, lace, feathers, silk, wool, cotton, etc., and the most delicate shades of silk, satin, etc., are not affected in the slightest degree when carbon tetrachloride is properly applied. It is, therefore, of peculiar interest for dry cleaning and cleansing establishments, who have heretofore used naphtha and benzine. Its remarkable solvent properties make it an extremely valuable constituent in rubber and gutta percha cement and in the rubber and gutta percha industries, likewise in the lacquer, varnish and paint remover industries, and for other similar and innumerable purposes. A carbon tetrachloride solution of sulphur chloride is a vulcanizing agent of great value. Chloride of sulphur is a yellowish red, oily liquid, having a specific gravity of 1.709, and mixes in all proportions with carbon tetrachloride, benzole, carbon disulphide, etc., also with petroleum or naphtha. It is used in the cold or dip process of vulcanizing rubber, in the preparation of rubber substitutes, artificial drying oils substitutes from Menhaden, and fish oils, corn oil, etc.; for the thickening of oils, rapid manufacture of printers' ink, etc.

Personal.

Mr. M. U. SCHOOP, the well-known European storage battery expert and electrochemical engineer, will arrive in this country on the steamship "Amerika," of the Hamburg-American Line, which is due in New York on Feb. 8. As noticed on page 338 of our issue of last August, Mr. Schoop has recently invented a simple practical method of autogenous welding of aluminium.

Digest of U. S. Patents.

Compiled by Byrnes & Townsend, Patent Lawyers, National Union Building, Washington D. C.

CARBORUNDUM.

No. 560,291, May 19, 1896, E. G. Acheson, of Monongahela City, Pa.

This patent describes an electric furnace, with modifications, for the production of carborundum in accordance with the general process of patent No. 494,767. The furnace is provided with a core, through which the electric current passes and to which it is largely restricted, the charge mixture being arranged in the furnace to receive its heat from the core in lines diverging from the direction of the path of the electric current, that is, as shown, around or upon the core, in contradistinction to those furnaces in which the charge is mixed with an electrically-conductive material. The core, while offering more or less resistance to the flow of the electric current, so that it will become sufficiently heated, is of lower resistance than the charge, so that little if any of the current shunts from the core through the charge.

The various furnaces illustrated each comprise a bottom and side and end walls of fire-brick, the side walls being laid up with loose joints to permit the free escape of gases, which burn at the points of escape and contribute to the heating of the charge. The two electrodes pass through the end walls, and each may consist of a number of spaced carbon rods, passing through openings lined with asbestos and connected externally by a terminal plate, or a single plate or block of

carbon, or preferably of a number of rectangular carbon bars, clamped together by a metal frame into a rectangular mass, practically filling the end of the furnace. Copper plates are placed between the outer ends of the cars and have terminal lugs, which are clamped together and connected with the electric main. The core may be a solid mass, but preferably consists of granular carbon, the sizes of the grains depending on the size of the furnace and the electric current used. In a furnace having a core 8 feet long and employing 100,000 watts, the core is preferably 10 inches in diameter, and consists of grains three-sixteenths of an inch in diameter, of coked bituminous coal. The form and electrical conductivity of the grains are changed by use so that it is desirable to form other cores, when constructed of these altered grains, of a smaller diameter than the original core. The size of the particles constituting the ends of the core is preferably less than in the body of the core, to effect more intimate contact with the electrodes. To assist in maintaining contact between the core and electrodes, weights may be placed on the ends of the core, that is, on the bodies of fine particles filling the spaces between the ends of the core and the electrodes and extending up to the top of the furnace. Or the core may lie upon a lining of fire-clay on the bottom of the furnace, the ends of the core then being compressed by the weight of the body of charge material above. The preferred charge consists of a mixture of carbonaceous, siliceous and fluxing materials, plus a substance which will add to the electrical resistance of the mass, render it more porous and aid in the escape of gases, specifically, by weight, 20 parts of finely divided coal or coke, 29 parts of sand, 5 parts of common salt and 2 parts of sawdust. These materials are intimately mixed, and are packed in the furnace so as to surround or cover the core practically throughout its length. The charge is generally placed directly in contact with the core, but layers of paper may be interposed. It is advantageous to use in the charge, as a source of carbon, a hydro-carbon, such as anthracite coal, the products of distillation of which act as a fuel to assist in heating the charge. The core forms the necessary groundwork for the growth of the crystals of carborundum, which are formed in a ring around the core, the original constituents of the charge disappearing as this ring increases in diameter. Shunting of the electric current from the core through the charge is detrimental to the production of the crystalline product. The heating of the charge is assisted by the combustion, not only of the gases distilled from the charge, but, to some extent, by the combustion of the carbon in that portion of the charge exposed to the air.

No. 650,234, May 22, 1900, F. A. J. Fitzgerald, of Niagara Falls, N. Y.

Carborundum is produced in the electric furnace in masses of coherent crystals of insufficient solidity for use in the arts, since the crystals occupy approximately the same space as the original charge, over 60 per cent of which disappears as gas or vapor. The crystals being of higher specific gravity than the charge, the masses are necessarily porous and loosely knit together. For use it is necessary to separate the loosely-held grains, add clay or other binder, and fire. The clay binder detracts from the value of the molded articles when intended for purposes exposing them to high temperatures.

The improved method of producing coherent masses of carborundum consists in mixing carborundum in grains or powder of proper size with a temporary binder, for example, thin glue, molding into shape and heating the molded mass in an electric furnace to about the temperature originally used to produce the carborundum. The carborundum then recrystallizes and the product is a very hard, dense mass, occupying substantially the same space as before forming, without substantial loss of material by volatilization, except that of the temporary binder. Refractory bricks, crucibles or abrasive products may be thus produced, consisting of practically nothing but carborundum. When a product having electric conductivity is desired, a mixture of graphite, 15 to 20 parts, and carborundum, 85 to 80 parts, or other proportions, may be used.

